U A U C U

Student Research Exchange *Collected Papers 2024*

University of Aruba

MEMORANDUM OF UNDERSTANDING
BETWEEN
UNIVERSITEIT VAN ARUBA (UA), ORANJESTAD, ARUBA
AND
UNIVERSITY COLLEGE UTRECHT (UCU), UTRECHT UNIVERSITY, THE NETHERLANDS

AGREEMENT

THIS AGREEMENT is made and entered into as of the 26th of February 2015 by and between UNIVERSITY COLLEGE UTRECHT, hereinafter designated as UCU, and UNIVERSITEIT VAN ARUBA, hereinafter designated as UA.

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Student Research Exchange

Collected Papers 2024

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Student Research Exchange

Collected Papers 2024

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Introduction to the ninth edition of the UAUCU Student Research Exchange Collected Papers

Aruba is a small island state where the sustainability challenges confronting the world are mirrored and magnified. These challenges have become even more pressing, in Aruba and elsewhere, since our first volume was published in 2015. This volume, like previous ones, documents the efforts made by student researchers from the University of Aruba and Utrecht University to grapple with these challenges in Aruba. It opens with a list of guiding principles and goals that these students compiled collectively in a UA classroom in February 2024, at the beginning of their 11 weeks together. The ideas in this list express our students' ambitions to do research in ways that would be meaningful to others as well as to themselves. These reflect the principles of community-based research that have been at the heart of our student research collaboration program since it was founded.

This year a total of 18 student researchers completed their paper for this publication. They are thesis year students from the University of Aruba's Sustainable Island Solutions through STEM program and the Organization, Management and Governance program, as well as from University College Utrecht and the Global Sustainability Science program at Utrecht University. As in previous editions, the topics of their research reflect the diverse backgrounds of their study programs, and relate to the sustainable development goals (SDGs) of the United Nations 2030 agenda. The works included here are grounded in fields ranging from engineering to data sciences and from anthropology to sustainability consultancy in diverse fields. The research aims to treat issues of sustainability in food security, waste management, renewable energy and resource management. The students supported each other's process while working on their own research, morally and practically, providing feedback on approaches to research, and on the content, style, language and structure of the papers submitted for this volume.

The individual rewards of participating in community-based research are reflected in the personal reflections that the students have written to preface their reports on their own research. The research papers appear as submitted by the authors, including the occasional raw or not yet developed conclusion. Some of the contributions reflect completed studies, others are preparatory explorations, proposals for research that is still be to carried out. All the authors are still working on interpretation and presentation of their findings and will finalize these in consultancy reports or bachelor theses based on the results of the projects presented here.

We prepared the students from Utrecht for their time in Aruba in a preparatory module (Community-engaged research in the Caribbean) offered at UU, where they developed their first research ideas. The students form Utrecht joined the UA students in a bachelor course (Interdisciplinary and multidisciplinary approaches to sustainable development in small island states) that served as a forum for mutual support and collaboration, and culminated in presentations of their work to the Aruban community in the UA Aula. Many others have also made crucial contributions to the students' success this year. We, and our students, appreciate the value and power of their contributions to this project as a whole. We want to express special gratitude to UA's Tobia de Scisciolo help in providing feedback on the papers in preparing them for publication here. Many others who have played crucial roles as guides, lecturers, mentors, advisors, facilitators, respondents, interview participants, and engaged citizens: thanks to you all! We hope that you have looked forward to the work that is presented in this volume as eagerly as we did!

Eric Mijts & Jocelyn Ballantyne
Project coordinators UAUCUU

Guiding principles 2024

Positivity
Be respectful of difference, of the community with whom we do our research, of each other’s time
Create space for sharing and transparency
Curiosity
Academic validity
Inclusivity
Be considerate
Be honest
Reciprocity
Emphasize quality
Accountability
Put in our best effort - and respect each other for it
Listen

Needs towards each other

Manage expectations
Share intercultural awareness
Help each other with academic skills
Engage in class
Holistic support
Encourage each other
Try to stay connected outside of class
Share social opportunities

Needs towards lecturers

Clarity on expectations
Encourage the students to do their best (including meeting deadlines)
Constructive feedback
Mediating contacts
Clarity on social relations

Introduction Global Sustainability Science Program

Six students from the Global Sustainability Science program at Utrecht University participated in the 2024 edition of the program. Their task was to support the Aruban Department of Agriculture, Livestock and Fisheries by developing strategies for the implementation of rainwater harvesting for agricultural and other purposes. The consult was presented in the aula of the University of Aruba in the presence of the Minister of Transport, Integrity, Nature and Elderly Care, Ursell Arends, as well as staff from different government departments of Aruba, farmers and other stakeholders. Consultancy Project Aruba–instructors Britta Ricker and Emmeline Long wrote the following reflection about the students' engagement:

"Your journey began on Monday February 5th 2024, when you all met at the University of Aruba to kick off your first week in Aruba and your course work there. At this first meeting we had rich discussions about life and sustainability with the students at the University of Aruba in the context of Aruba. This week you also got started with the UU consultancy project with your client Nathalie Maduro, the Director of the Department of Agriculture, Livestock and Fisheries. Nathalie took us on a tour of their impressive facilities at Santa Rosa, where they provide resources for farmers from animal husbandry, experimenting with different plant and tree species, composting, a petting zoo for children, examples of rainwater harvesting and more. This became your homebase.

While Britta had to return to the Netherlands after this first kick off week, you continued to work hard conducting qualitative research about the feasibility of rainwater harvesting for your client Nathalie Maduro. This distance meant that Emmeline and I did not always have all the local context. This meant that we analyzed your work with a critical eye for detail and high research standards. In the end, you met our standards and made your client very happy with the useful research results your offered. It was a pleasure to bear witness to your intellectual and professional growth over the duration of this course, even at a distance. We look forward to seeing where your professional pursuits take you next.

The kick off week also included a Sustainable Island Tour. When Aruba comes to mind, the first thing that comes to mind are the beaches. However, by area, the largest landcover type in Aruba are Tropical Dry Forests (TDF). TDF offer a wealth of biodiverse habitats, productive carbon sequestration services, and they are among the most endangered and under-researched ecosystems on Earth. Naturally, Eric took us on a hike to experience this unique landscape up close in the Arikok National Park. While we did not meet any other human hikers, a friendly trail dog decided to join our class field trip for the day. On this hike we saw flowering cactus, owls and other unique birds, we discussed how goats have changed the vegetation, we say the historic remains of a farm and mill, beautiful vistas of the island at the crest of a small mountain, and more."

Follow this QR code to surf to some images and the posters presented at the 2024 UAUCU symposium at the University of Aruba.

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Isabelle Ruiz, University of Aruba

We liked talking trash during class.

As we near the end of this class, it's interesting to look back on how uncertain I was in the beginning. The course had a very long name that didn't give much indication of what to expect, but now it all makes sense. From the very first week, which was packed with activities and field trips, I knew this class would be memorable. During our time in Leuven, we were repeatedly reminded to choose a topic and eventually encouraged to participate in a poster event with the UCU/UU students. In hindsight, I'm glad we were pushed to pick a topic and engage in discussions with different people, each offering their own perspectives. Throughout the course, we had many conversations that made us think and, at times, surprised me when the exchange students knew more about certain aspects of Aruba than I did. The collaboration between the exchange students and the local ones brought us all closer together and expanded our horizons. I found inspiration in others and even surprised myself with how much information my mom brain retained. Some of my favorite topics discussed turquoise economy, biodiversity, donut economy, food security, and of course waste. (we liked talking trash during class)

At the beginning of the course, we had written some kind of agreement between the students and lecturer, and this solidified the mutual understanding, respect, trust, and shared objective of improving the world to some extent. The entire encounter with the visiting students, fellow educators, and Professor Mijts is something I genuinely value for the wisdom and experience gained throughout this course. While there were moments of difficulty, I cannot imagine undertaking this endeavor with any other group of individuals who share similar beliefs (aka "mini Eric's", just kidding!), and friendship that has been made. As I contemplate this initial article for this class, I recognize areas where additional support may be necessary and the direction in which I would like to proceed with this research topic for my thesis.

Offshore Wind Generator Possibilities in Small Island States; Preliminary Results

Isabelle Ruiz

Introduction

Aruba is a small island developing state (SIDS) (United Nations, 2022), located in the southwest Caribbean Sea (Hoetink, 2024). Like many small island states, Aruba faces significant challenges in meeting its energy demands due to heavy reliance on imported fossil fuels in the form of Heavy Fuel Oil (HFO) and Light Fuel Oils (LFO). This makes the island's energy production dependent on fluctuating prices and the uncertainties of international trade and geopolitical (in)stabilities. The world is shifting from fossil fuels towards renewable energy due to the urgent need to mitigate climate change and ensure energy security. Aruba, a self-declared pioneer in renewable energy development, particularly in wind energy, is a good candidate due to the trade winds, which provide a constant uniformity of direction and speed (Meteorological Basis for Aruba Winds, 2017). Aruba is densely populated and also grapples with limited land space, being only 19.6 miles long and six miles across, totaling a mere 75 sq miles (Jurgens et al., 2024).

This study explores the possibilities of harnessing wind energy through offshore wind turbines instead of on land. By utilizing previous research and literature on wind energy in the region alongside new and upcoming technologies in wind generator technology, this study seeks to provide a comprehensive understanding of the opportunities and challenges associated with wind turbine implementation in Aruba.

The importance of renewable energy in reducing greenhouse gas emissions and mitigating the impact of climate change cannot be overstated (Sayigh, 2024); however, supplying the country with renewable energy also increases energy security. The trade winds are a powerful supply of energy, with only 10 turbines, Aruba currently produces 14.4% of its total electricity (WEB Aruba N.V., n.d.). Aruba holds great potential for wind energy as a sustainable alternative to fossil fuels. Understanding the feasibility, technological advancements, economic implications, and regulatory frameworks surrounding wind turbine projects in Aruba is crucial for policymakers, investors, and stakeholders involved in the energy sector.

The main research question this study aims to answer is: What are the possibilities and challenges associated with harnessing wind energy through wind turbine installations in Aruba? This is a complex question as it requires a deep understanding of various aspects related to wind energy in Aruba, including the geographical and climatic conditions influencing wind generation possibilities, technological advancements in wind generation, economic/cost analysis, environmental impact, and sustainability considerations, policy, and regulatory frameworks, as well as social acceptance and community engagement. Through this review, we hope to shed light on the opportunities and challenges in harnessing the wind's power to propel Aruba towards a cleaner, greener, and more sustainable energy future.

Methodology

This preliminary study primarily relies on a comprehensive review of existing literature, including academic journals, research papers, newspaper articles, government reports, and industry publications, to gather relevant information on wind energy development in Aruba. The literature review will explore various aspects of wind energy implementation in Aruba, including geographical and climatic factors, current wind energy projects, advancements in wind turbine technology, economic feasibility, environmental impact, policy frameworks, social acceptance, community engagement, challenges, and opportunities. The search for relevant literature will be conducted using online academic databases like Google Scholar, Research Gate, Google, and institutional repositories, focusing on keywords related to wind energy, Aruba, offshore wind turbines, geographical and climatic conditions, technological advancements, economic analysis, environmental impact, policy frameworks, social acceptance, and community engagement.

It is important to acknowledge potential limitations associated with the literature review methodology. These may include publication bias, language limitations, and lack of availability of relevant literature as only limited literature is available that focuses on the specific circumstances of the Aruban context.

Geographical and Climate Factors

To effectively utilize wind turbines for wind energy, it is necessary to understand Aruba's geographic characteristics and climate conditions. This is crucial for assessing the feasibility and practicality of wind energy projects, as these projects are quite costly and the climatological variables are important determinants of technical characteristics and the life cycle of the solutions that are implemented.

Aruba is located in the southern Caribbean Sea and is conveniently positioned in the path of the trade winds. This means that the island consistently receives a steady and dependable supply of wind, making it an attractive location for wind energy development. The topography of Aruba is mainly flat, with the highest point being Mount Jamanota, which reaches just over 600 feet above sea level. This relatively flat terrain allows for unobstructed wind flow across the entire island, although wind speed may vary depending on the specific location and topography.

While slight variations in wind velocity can occur due to seasonal factors and the surrounding landscape, the average wind speed typically ranges from 15 to 20 miles per hour. The Vader Piet windpark has a capacity of 30MW, producing around 106742 MWh to 175244 MWh per year for that specific location and wind turbines.

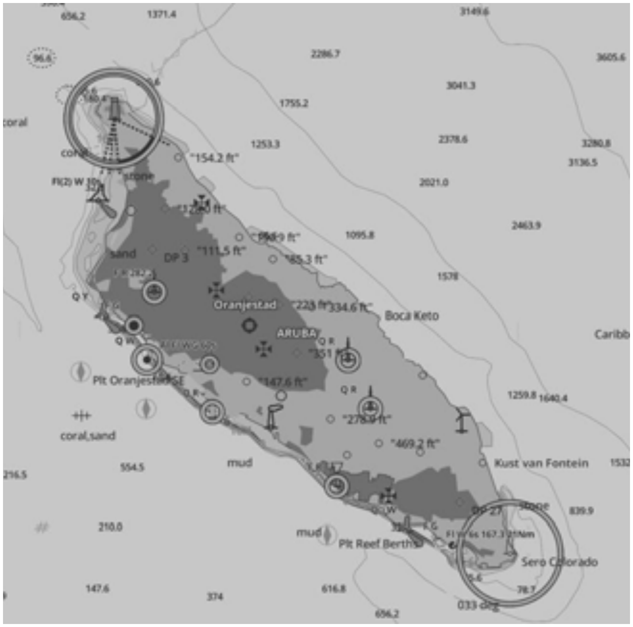


Figure 1. Aruba Marine chart, indicating the depth of water in ft surrounding Aruba (GPS Nautical Chart, n.d.).

As the island is densely populated, there are challenges to the expansion of wind energy generation on the land. The option that we explore in this study is a shift in the development of wind energy from land to the surrounding ocean. However, the Aruban territorial waters get deep, quite fast. As seen in Figure 2, Aruba has the potential for floating wind turbines considering the depth of its waters.

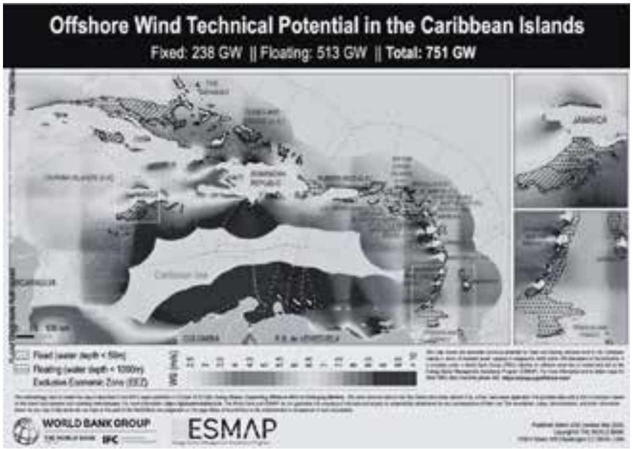
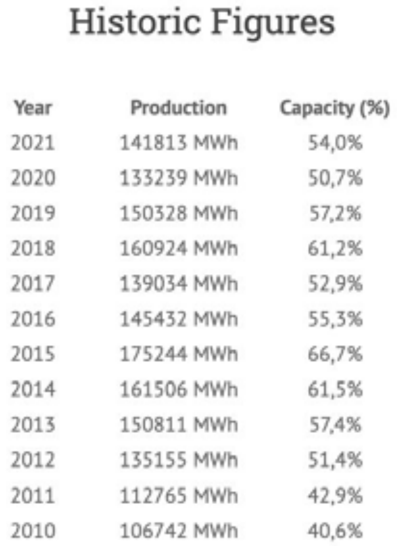

Offshore Wind Technical Potential in the Caribbean Islands
Fixed: 238 GW || Floating: 513 GW || Total: 751 GW
Caribbean Sea
JAMAICA
Fixed (water depth < 50m)
Floating (water depth < 1000m)
Exclusive Economic Zone (EEZ)
WORLD BANK GROUP
ESMAP

Figure 2. Offshore wind technical potential in the Caribbean Islands. Adapted from The World Bank, 2020

Current Status of Wind Energy Projects

Aruba has made significant strides in developing wind energy infrastructure, with an operational wind farm that is contributing to 14.4% of its energy demand (WEB Aruba N.V., n.d.). Since 2010, Windpark Vader Piet has produced an average of 142 GWh annually, the wind park was commissioned in 2009 and features a series of wind turbines located on the island's northeast coast. Moreover, there were plans for Urirama Wind Farm, which was supposed to be inaugurated in 2015, however, the strong resistance from local citizens stopped the project. The Vader Piet Wind Park is the result of a collaborative effort between the government of Aruba and international partners (Hutting Windenergie, Nucapital, Bright Capital Partners, Dexia, and Eksport Kredit Fonden (EKF)) to expand the island's renewable energy capacity. Windpark Vader Piet is one of the best-performing wind farms worldwide (Wind Park Vader Piet, 2023). The current wind farm has a capacity of 30 MW, however, according to Vader Piet's website (Wind Park Vader Piet, 2023), *"Aruba can easily triple the wind energy production, by adding a new comparable but more efficient line of wind turbines"*.



Historic Figures

Year	Production	Capacity (%)
2021	141813 MWh	54,0%
2020	133239 MWh	50,7%
2019	150328 MWh	57,2%
2018	160924 MWh	61,2%
2017	139034 MWh	52,9%
2016	145432 MWh	55,3%
2015	175244 MWh	66,7%
2014	161506 MWh	61,5%
2013	150811 MWh	57,4%
2012	135155 MWh	51,4%
2011	112765 MWh	42,9%
2010	106742 MWh	40,6%

Figure 2. The energy generation per year and the capacity in %. (Windpark Vader Piet, 2023)

Technological Advances in Wind Turbines

Several wind turbine technologies are suitable for harnessing wind energy effectively in Aruba. To withstand the harsh salty climate in combination with high wind speeds, the current wind turbines in Vader Piet are offshore wind turbines. These offshore wind turbines are specifically designed to withstand the marine environment, including high winds, saltwater corrosion, and wave forces. They are typically larger and more robust than onshore turbines and, when installed in the ocean, are anchored to the seabed using fixed or floating foundations. Offshore turbines benefit from stronger and more consistent winds compared to onshore sites, resulting in higher and more consistent energy production.

In deeper waters, floating wind turbines can be installed, these are a type of offshore turbine that can be deployed in deeper waters where fixed foundations are not feasible due to the depth. These turbines are tethered to the seabed using mooring lines and buoyant platforms, allowing them to float on the surface. Floating turbines offer flexibility in siting and can access wind resources further offshore, where winds are typically stronger and more consistent.

An option to consider for the Aruban waters would be the Vertical Axis Wind Turbines (VAWTs). These turbines have a vertically oriented rotor shaft and blades that rotate around a vertical axis, unlike traditional horizontal axis turbines. VAWTs are suitable for locations with turbulent or variable wind conditions and well-suited for coastal areas where wind patterns may vary. They also have a lower visual impact due to less height and are easier to maintain compared to horizontal axis turbines. This concept lends itself perfectly to floating wind farms as the turbine's center of gravity is much lower. This makes the floating construction lighter and cheaper (Thorpy, 2022).

Recent advancements in turbine design have significantly boosted their economic viability and comparative competitiveness with conventional energy sources. These cutting-edge developments include larger rotor sizes, allowing higher power output and operational efficiency through the swirling wind captured, and major improvements in retrofitting control systems such as pitch (adjustment of blade angle for optimal wind capture), yaw (orientation of the turbine to face the wind), and rotor speed (regulation of turbine rotation) technology. Different techniques for improving gearboxes can increase the turbines' dependability. The reliability of turbines is improved through the use of gearbox advancement techniques. Additionally, offshore solutions like floating platforms (such as spar buoys or semi-submersible platforms), monocles (monopiles), and jackets (lattice structures) have revolutionized the ability to expand water depth boundaries. These solutions also help reduce upkeep costs, increase turbine uptime, and provide new opportunities for deploying turbines in deeper areas of offshore wind reserves. The global weighted average cost of electricity for onshore wind fall was 69 percent to USD 0.033/kWh in 2022, slightly less than half that of the cheapest fossil fuel-fired option in 2022 (IRENA, 2023).

Altogether, technological advances coupled with favorable wind conditions in Aruba's territorial waters present promising opportunities for the deployment of advanced wind turbine technologies to support the island's transition to a sustainable energy future.

Economic Benefits

The economic benefits of wind energy projects in Aruba compared to traditional fossil fuel energy sources are cost competitiveness, wind energy has become increasingly cost-competitive with fossil fuel energy sources such as fossil fuels. As technology advances and production becomes commercialized, the levelized cost of electricity (LCOE assesses the lifetime cost of generating electricity from a particular energy source, taking into account all relevant costs such as initial investment, operation and maintenance, fuel, and financing costs. LCOE is often used to compare the cost competitiveness of different energy generation technologies.) wind power has decreased significantly, making it comparable to or even cheaper than electricity generated from fossil fuels, about half as much. Wind energy offers greater price stability compared to fossil fuels, which are subject to fluctuating market prices influenced by geopolitical factors, supply disruptions, political factors, and fluctuations in global oil and gas markets. By investing in wind energy projects, Aruba can secure energy security and achieve greater energy price stability over the long term. This would also decrease the heavy reliance on imported fossil fuels for electricity generation which exposes the island to external supply risks and vulnerabilities. The development of wind energy initiatives generates employment prospects, as individuals may either acquire new competencies needed for the establishment or convert their existing expertise to aid create opportunities for economic progress. The transition to renewable wind energy reduces CO2 emissions and contributes to a cleaner environment for the local population. I presume that the price of energy production matches the rate per kWh of Afl.0.3580 from Elmar (Elmar N.V., n.d.). The mean worldwide cost of power from large-scale onshore wind energy is USD 0.033/kWh =Afl.0.05775/kWh, recognized by IRENA (2023). Although the offshore wind generator's figure could not be traced, I present the onshore wind power cost.

Environmental benefits of wind energy in Aruba

Implementing offshore wind turbines will reduce the amount of greenhouse gases emitted. Reducing Aruba's carbon footprint and mitigating climate change. Furthermore, wind energy reduces air pollution that you would typically get by combusting fossil fuels (Heavy Fuel Oil HFO is primarily used in Aruba, kg CO2/kWh= 0.27). Fossil fuels emit harmful pollutants such as carbon dioxide, sulfur dioxide, and nitrogen oxides along with other particulate matter. Improving air quality enhances public health and reduces respiratory illnesses and other negative health impacts associated with air pollution. By expanding the wind energy (taking the energy production in 2021) *3 (by three times), 141,813,000 kWh * 3= 425,439,000 kWh * 0,27= 114,863,530 kg CO2. it will have a yearly 114,863,530 kg CO2 reduction compared to HFO.

Offshore wind turbines have a minimal ecological impact in comparison with fossil fuels. They also occupy a small area which can be shared with nature. By minimizing habitat destruction and environmental degradation, wind energy supports ecological sustainability and biodiversity conservation in Aruba. However, there are also potential environmental concerns with offshore wind turbine installations. These include the impact on marine ecosystems, including disruption of fish and marine mammal habitats, disturbance of migratory patterns (birds and bats), and underwater noise pollution during construction and operation.

To mitigate these concerns, environmental impact assessments (EIAs) should be conducted to identify sensitive habitats and species, and appropriate measures implemented to minimize impacts, such as seasonal construction restrictions, and noise mitigation technologies, and to compensate environmental impacts by measures such as habitat restoration programs. Additionally, there are risks associated with offshore wind turbines due to possible collision risks for birds and bats, particularly during migration periods or in areas with high avian activity. To mitigate collision risks, pre-construction surveys can be conducted to assess bird and bat populations and to identify high-risk areas. Turbine placement and operational measures, such as radar-based bird and bat detection systems, curtailment during peak migration periods (The deliberate reduction or limitation of electricity generation from wind turbines. This may occur due to factors such as grid constraints, oversupply of electricity, or operational requirements, to manage grid stability and optimize energy utilization), and habitat restoration initiatives can help minimize collision risks and protect avian and bat species.

Social Acceptance and Community Engagement

The local community of Aruba has shown in the past, that they can be a decisive factor in the implementation of wind energy projects. If they feel they are misinformed and want to keep their undisrupted view, protests will happen and projects will not go through. This happened during the last years when in 2011 and 2012 the Urirama protests unified Aruba's environmental, and residential, and religious communities against a wind farm project. When the project was announced toward the end of 2011, NGOs and local communities raised questions about the impact of the project on the environment, the livelihood of the residents of the area, and the proximity to the religious-cultural site of Alto Vista (e.g. Amigoe, 2011).

Providing transparency throughout the preparation and implementation of a project, including the potential environmental impacts of offshore wind turbine installations, such as visual intrusion, noise pollution, impacts on wildlife, and habitat disturbance, can positively influence community perceptions. Conducting thorough environmental impact assessments, and implementing mitigation measures to address these concerns are essential for building trust and securing community acceptance. Effective stakeholder engagement is critical for building community support and addressing concerns related to wind energy projects. Engaging with residents, indigenous communities, fishermen, tourism operators, environmental organizations, and other stakeholders through open dialogue, consultation meetings, public hearings, and participatory decision-making processes can help identify concerns, gather input, and build consensus around project development. Educating the community with simple but accurate, accessible, and understandable information about offshore wind energy projects, their benefits, potential impacts, and mitigation measures is essential for fostering community understanding and support. Education and awareness-raising campaigns, public outreach events, informational materials, and community workshops can empower residents to make informed decisions and participate meaningfully in the decision-making process.

Challenges and Opportunities

Offshore wind energy production in Aruba faces challenges due to the depth of territorial waters and the intermittent nature of wind energy generation. However, Aruba has abundant renewable energy resources that can diversify the energy mix and reduce reliance on imported fossil fuels. Implementing supportive policies and involving stakeholders early in the planning process can attract investment and foster market growth. Flexibility and adaptability in project design and technology selection are key to overcoming challenges and seizing emerging opportunities. Offshore wind energy projects can bring economic benefits such as job creation, local investment, and tax generation.

Conclusion

In conclusion, harnessing wind energy through wind turbine installations in Aruba presents both significant possibilities and challenges. This preliminary exploration has highlighted various aspects related to wind energy development in Aruba, including geographical and climatic factors, the current status of wind energy projects, technological advances in wind turbines, economic benefits, environmental impact and sustainability considerations, social acceptance, community engagement, as well as challenges and opportunities.

Aruba's geographical location and topography, characterized by its flat terrain and consistent trade winds, make it an ideal candidate for wind energy development. The island's existing wind farms, such as Windpark Vader Piet, demonstrate the effectiveness of harnessing wind energy to contribute to the energy mix, with the potential for further expansion and increased efficiency through technological advancements.

Technological advances in wind turbines, including offshore and floating turbines, offer promising opportunities for the development of wind energy generation in Aruba's territorial waters. These technological advancements, coupled with favorable wind conditions, present a pathway towards a more sustainable energy future for the island.

The economic benefits of wind energy projects in Aruba, including cost competitiveness, energy price stability, job creation, and reduced reliance on imported fossil fuels, underscore the importance of transitioning towards renewable energy sources. Furthermore, wind energy offers significant environmental benefits, including the reduction of greenhouse gas emissions, air pollution, and habitat destruction, contributing to climate change mitigation and ecological sustainability.

However, challenges such as the depth of Aruba's territorial waters, intermittent wind energy generation, and the need for advanced technology and infrastructure pose significant hurdles to overcome. Addressing these challenges requires robust policy and regulatory frameworks, stakeholder engagement, transparency, and community involvement throughout the project development process.

In conclusion, while the shift towards harnessing wind energy in Aruba may come with challenges, the potential benefits for the island's energy security, economic prosperity, and environmental sustainability are considerable. By leveraging existing resources, embracing technological innovation, and fostering collaboration among stakeholders, Aruba can pave the way toward a cleaner, greener, and more sustainable energy future.

References

- Amigoe. (2011, November 9). 09-11-2011. Amigoe di Aruba. Biblioteca Nacional Aruba.
- Elmar N.V. (n.d.). *Rates - Rates*. N.V. ELMAR Aruba. Retrieved April 15, 2024, from https://www.elmar.aw/your-electricity-statement/rates
- GPS Nautical Chart. (n.d.). *A Aruba (Marine Chart : CB_NC_0702_1) | Nautical Charts App*. GPS Nautical Charts. Retrieved April 15, 2024, from https://www.gpsnauticalcharts.com/main/cb_nc_0702_1-a-aruba-nautical-chart.html
- Hoetink, H. (n.d). *Aruba | History, Map, Flag, Population, Climate, & Facts*. Britannica. Retrieved March 27, 2024, from https://www.britannica.com/place/Aruba
- IRENA (2023), Renewable power generation costs in 2022, International Renewable Energy Agency, Abu Dhabi
- Jurgens, S., Mijts, E., & Van Rompaey, A. (2024, February 13). *Are there limits to growth of tourism on the Caribbean islands? Case-study Aruba*. Frontiers. Retrieved April 15, 2024, from https://www.frontiersin.org/articles/10.3389/frsut.2024.1292383/full
- Meteorological Basis for Aruba Winds. (2017, November 9). *Meteorological Basis for Aruba Winds*. Retrieved April 2, 2024, from https://www.bywindkal.com/Files/ArubaWinds.pdf
- Sayigh, A. (2024, March 5). *Up-date: Renewable energy and climate change*. Retrieved April 15, 2024, from https://www.rees-journal.org/articles/rees/pdf/2021/01/rees210008.pdf
- The National Renewable Energy Laboratory. (2015, March). *Energy Snapshot Aruba*. NREL. Retrieved April 2, 2024, from https://www.nrel.gov/docs/fy15osti/62709.pdf
- Thorpy, M. J. (2022, September 12). *1-MW floating vertical axis wind turbine to be deployed off Norway.* New Atlas. Retrieved April 15, 2024, from https://

newatlas.com/energy/seatwirl-vawt-norway/

- United Nation. (2022, December). *List of SIDS .:. Sustainable Development Knowledge Platform*. Sustainable Development Goals. Retrieved March 27, 2024, from https://sustainabledevelopment.un.org/topics/sids/list
- WEB Aruba N.V. (n.d.). *Water- en Energiebedrijf Aruba N.V.* WEB Aruba N.V. | Water- en Energiebedrijf Aruba N.V. Retrieved April 15, 2024, from https://webaruba.com/energy/power-production-figures
- Wind Park Vader Piet. (2023, December 23). Windpark Vader Piet: Home. Retrieved April 3, 2024, from https://www.windparkvaderpiet.com/
- The World Bank. (2020, March). *Offshore Wind potential | Caribbean Islands*. Retrieved April 15, 2024, from https://energycentral.com/c/cp/offshore-wind-potential-caribbean-islands

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A swim in the ocean every day?

“A swim in the ocean every day?” This was the challenge I attached to my 16-week stay in Aruba. However, it quickly became clear that this was not a challenge, but merely a habit in my daily life. The ocean served as my happy place for everything - whether it was a beach day with friends, kitesurfing, snorkeling, lap swimming, jumping off a cliff or even finding inspiration for my thesis. Upon arrival in Aruba, beach days started with long walks in the heat, but soon with our beautiful car Carlos, we quickly visited every beach to be discovered in Aruba. Besides the beach, the way of living in Aruba is something I could definitely get used to. We took the days hour by hour, hopping in the car barefoot, bikinis and sunglasses on, snorkels and a kite in the boot, and seeing where the day would take us. Many of these days did somehow always turn out to be early hours at the university or hiking, avocado toast for lunch, an afternoon at the beach, and a cold curry at sunset.

Many weekends were also spent on the beach tennis courts of Aruba, participating in tournaments and supporting one another. Especially the tournament when Ella and I won the women’s beginner doubles will forever be remembered (the infinite bananas and cookies definitely did us good on that one). I will also always remember Aruba as the place where I finally picked up kitesurfing. Besides being known as the girl who somehow always found her way to Panama, and having a few boat pickups, it taught me so many new things. The kitesurf community showed me the elements of generosity, kindness and caring countless times. But these elements extended beyond the kitesurfing community too, because in general everyone in Aruba is so relaxed and extremely kind hearted.

The journey in Aruba also extended beyond just hours at the beach and in nature; it was also an extremely good learning process in various ways. I learnt a lot about myself and others, the type of lifestyle I want to pursue, how to cook meals on one hotplate, and how to navigate independent research and thesis writing. Conducting field research is exhilarating but also scary and overwhelming. There have definitely been moments where I could not find motivation to work (especially being on an island…) as well as struggling conducting my research, but through the support of other students and friends, it all works out! I couldn't have done this all without everyone else, and especially not without Ella, both my roommate here and best friend, who was my inspiration, my source of adventure, and who made these months unforgettable.

Caught in the Net of Global Transformations: Vulnerabilities and Challenges facing Artisanal Fishing Communities in Aruba

Claire Durang

Introduction

While Aruba's coastline serves as the cornerstone of its economic survivability, driving economic growth through tourism, the diverse marine life and ecosystems within its waters are of equal significance. However, arguably these ecosystems and marine life are not receiving the appropriate attention proportionate to their value. The provision of fish supplies, and the well-being of sea turtles, coral reefs, and fish amongst others, serve as vital factors to Aruba's economy. The well-being of marine ecosystems is especially important to the tourist industry and artisanal fishing communities in Aruba. Artisanal fishing refers to small-scale fishing with traditional, implying wooden or fiberglass boats, with outboard gasoline engines (Boekhoudt, 2012). Marine biodiversity is being threatened internally by tourists and institutions, and externally by global transformations, including climate change, transitions to sustainable tourism and environmental degradation. These internal and external pressures confront the artisanal fishing communities in Aruba with numerous vulnerabilities and challenges.

This paper aims to uncover vulnerabilities and challenges Aruban artisanal fishers are facing while exploring how global transformations impact their practices and local responses. Given Aruba's heavy reliance on tourism for economic growth, much of its focus is on positioning itself as a tourist destination. However, as a small island state (SIS), Aruba is affected severely by the conflicts arising from global transformations in the 21st century, particularly in the tourism and environmental sectors. Environmental regulations are on the rise, urging institutions like the Aruba National Park Foundation to initiate environmental protection. The implementation of Marine Park Areas (MPA) in Aruba highlights this trend, as it aligns with various sustainable development goals while also necessitating careful consideration of its impact on tourist activities and artisanal fishing communities.

Artisanal fishing communities in Aruba serve as a crucial case study to unpack due to the unique characteristics of small island states, which require more academic attention. This research addresses a significant gap in the literature by examining how global transformations impact traditional practices within fishing communities. As Aruba navigates compliance with environmental treaties while ensuring economic prosperity, it's vital to consider the needs of artisanal fishing communities to prevent their marginalization.

2. Methodology

This research is implemented with a community-based approach and includes a 10-week field research period carried out in Aruba. Community-based research revolves around the three components of collaboration, participation, and action. All three of these components have been implemented in the research undertaken in Aruba. Alongside these components, community-based research also emphasizes the need for participation, involving the community and enforcing mutual learning processes. This field research will consist of qualitative data, through the following methods.

This paper outlines the starting point of a larger research project. For this paper, a literature review was conducted to support the field research that will follow. This literature review analyzed existing literature on the challenges that SIS face, and an analysis of both Aruba's preliminary marine park area management, and Bonaire's final marine park area implementation. This allows for a greater understanding of the challenges that SIS face concerning tourism, fisheries, and sustainability, as well as what possible effects the implementation of marine park areas will have on Aruba's fishing communities. Following this literature review, two semi-structured interviews were set up. The first interview was scheduled with Sietske van der Wal, the interim marine park manager of Fundacion Parke Nacional Aruba (FPNA). This interview was recorded as well as transcribed, to be used in later stages of this research. The second interview was with Byron Boekhoudt, the officer in charge of fisheries in Aruba, under Santa Rosa, the Governmental Department of Agriculture. This interview was neither recorded nor transcribed, due to the customary norms of discussing the matter in a conservation-based manner. Both these interviews were purposefully scheduled, after identifying key stakeholders for this research. The two interviewees were also purposefully chosen from different sectors to accommodate a range of different perspectives and insights to this research.

Besides the analysis of existing literature and interviews conducted at the start of this research phase, other research methods are still to be implemented. It is key to involve stakeholders from the artisanal fishing communities, and thus the next steps in this research will be interviewing these key stakeholders. The first step in this phase was the submission of a press release where a personal introduction was given alongside the purposes and aims of this research. The purpose of this press release was to provide an advanced notice, to avoid the visits coming as a shock. During the visits, a brief introduction will be given, followed by a few questions about their fishing practices, their fish stocks, and their experiences. Afterward, three points of contradictions, that were identified as a result of the two interviews, will be presented neutrally, hoping to gain the perspective of the fishermen on these matters.

Important ethical considerations for this research are respecting the boundaries and cultural values of key stakeholders from the artisanal fishing communities. With the press release, for example, stakeholders would be prepared for the visits and were assured that this research was not affiliated with either government organizations or conservation organizations. Furthermore, to guarantee ethical procedures, consent was asked before conducting interviews and when talking to stakeholders, to ensure their insights could be used in this research.

3. Literature Review

3.1: Introduction

Small island states (SIS) are characterized by a unique set of features, which create challenges for achieving sustainable development (Sachs et al., 2021). Their size, remoteness, limited resources, small market sizes, and exposure to external climate shocks jeopardize the well-being of islands (Sachs et al., 2021). The internal characteristics of the islands, combined with the global transformations that are occurring in the world, are catching the artisanal fishing communities in Aruba in the middle. Artisanal fishing methods face dual threats from shifting climate patterns and the delicate task of accommodating various sectoral demands. Among these sectors, the tourism industry poses a significant challenge as its activities often result in environmental harm, affecting marine ecosystems. Similarly, regulations aimed at conserving Aruba's biodiversity within the nature-conservation sector also impose constraints on the practices of fishing communities. Finding a balance between achieving both economic and environmental goals has been harder than expected, and the artisanal fishing communities are one to feel these repercussions in Aruba.

The selected academic articles focus on SIS's insular sustainability challenges and their impact on achieving sustainable development goals. This contains the relationship between tourism and climate change, and between fisheries and climate change. Emphasis is placed on the comparison of Aruba's and Bonaire's marine park management approaches, to gain a deeper comprehension of how the implementation of marine park areas can and will affect fishing practices. Only scholarly sources were considered to ensure credibility and reliability.

3.2: Challenges to Sustainable Development in SIS

The challenges that SIS face in attaining sustainable development differ depending on their location, and for this reason, this literature review focuses solely on SIS in the Caribbean to ensure adequate relevance of the literature to Aruba's context (Uitto et al., 2017). The most significant findings from existing literature revolve around how climate change threatens the well-being of SIS in the Caribbean (Lenderking et al., 2020). Literature on various adaptation and mitigation strategies that could be implemented in Caribbean SIS exists. Impacts of climate change affect various sectors including tourism and fisheries (Lenderking et al., 2020). This literature review will delve into the effects of climate change in these two sectors, exploring various adaptation and mitigation strategies through a case study of Aruba.

3.2.1 Tourism and Climate Change

Spencer (2018) addresses the increasing acknowledgment of the complex relationship between tourism and climate. Warm temperatures, predictable rainfall, clear waters, and low health risks were identified to be the highest pull factors of tourists (Spencer, 2018). The rise of sea levels, beach erosion, the well-being of coral reefs, and the increase of jellyfish, however, are all direct consequences of climatic shifts and in turn also pose as push factors for tourists (Spencer, 2018). Environmental conditions are an important factor that tourists take into when deciding which country to visit, but the presence of these tourists also causes deterioration of the environment. In Aruba, the relationship between tourism and climate is very clear, as many tourists come for Aruba's coastal beauty and tropical weather. Aruba's high dependence on tourism is thus also evident across all sectors; whether this is in the hotels, restaurants, on the beach, or the national park, there are tourists everywhere. Since many tourist activities take place on the coast, including the rental of jet skis or boats, snorkeling, swimming, and parasailing, extensive coastal development and investment in coastal infrastructure are required. Given that tourists are the driving force behind Aruba's economy, the constant influx of visitors poses significant threats to the environment, making the tourism industry unsustainable.

The use of UTVs (utility-task vehicles) and ATVs (all-terrain vehicles) by tourists, has done significant damage to the environment (Stevens, 2019). The Fundacion Parke Nacional Aruba (FPNA) released an environmental impact report for off-road driving (ORD) in the Arikok National Park, in 2020 (Fundacion Parke Nacional Aruba, 2020). The FPNA advocates for conservation and in doing so increases and protects the biodiversity of the island (Fundacion Parke Nacional Aruba, 2020). Island tours in the form of ORD were offered, resulting in over 715 vehicles passing through certain areas of the Arikok National Park daily (Fundacion Parke Nacional Aruba, 2020). The extensive practice of ORD however puts immense pressure on Aruba's natural resources, harming the vegetation, soil stability, water infiltration, and nutrient cycling through the dust clouds created by ORD (Fundacion Parke Nacional Aruba, 2020). ORD also had vast impacts on marine life, as the sedimentation and eutrophication reduced and negatively impacted water quality, impacting fish and crustaceans amongst other flora and fauna (Fundacion Parke Nacional Aruba, 2020). The effects on biodiversity, on several ecosystems, and the health of flora and fauna resulted in the creation of the FPNA policy document on managing nature conservation and high-impact motorized traffic (Policy Document, 2020). Policies included a curtailment of new registrations of motorized tour operations, the ban of all motorized vehicles, limitations on caravan sizes and daily entries, and several other regulations (Policy Document, 2020). With the implementation of these policies, Aruba has effectively implemented adaptation strategies to target unsustainable tourism.

The existence of this policy document highlights how tourism is having expansive effects on the environment, affecting flora, fauna, marine ecosystems, and land suitability. Since Aruba is defined by its SIS characteristics, the implementation of such policies must be executed through a holistic approach, considering other factors. This includes their economic dependence on tourism; a full ban on ATV and UTV tours would have caused a huge loss in employment and income. Including tourists in adaptation, policies is crucial; informing them about the ban on ORD driving enhances their self-assurance about sustainable tourists. They will feel a sense of contribution to climate change mitigation, instead of being subjected to strict regulations from external stakeholders (Spencer, 2018).

The detrimental impact of both land-based and coastal tourist activities on the environment has become increasingly apparent. This holds relevance for this research as it sheds light on the endangerment of marine life and highlights tourism's significant role in environmental degradation. This understanding is crucial for this investigation, which aims to examine the extent to which artisanal fishing communities are impacted by tourism activities and the future establishment of Marine Park Areas (MPAs).

3.2.2 Fisheries and Climate Change

Having established the extent of tourists' role in environmental harm, it is important to examine the role climate change is having on SIS. Changing climate patterns are creating vulnerabilities in fisheries and food security in SIS (Lenderking et al., 2020). Vulnerability in this context is the 'degree to which a system is susceptible to and is unable to cope with adverse effects' (Lenderking et al., 2020). There are several biophysical and socio-economic indicators used to assess what and who is vulnerable to the repercussions of climate change (Monnereau et al., 2021). The use of definitions and assessments has increased awareness about countries and sectors vulnerable to climate change (Monnereau et al., 2021). This awareness is vital as fishing communities are one of the most impacted, which in turn also affects food security, employment, and the livelihoods of many people (Monnereau et al., 2021). The consequences are also important to determine adaptation strategies in battling climate-induced disasters. Through the use of the vulnerability framework, implemented by Allison et al., 2009, the impacts of climate change on SIS will be assessed.

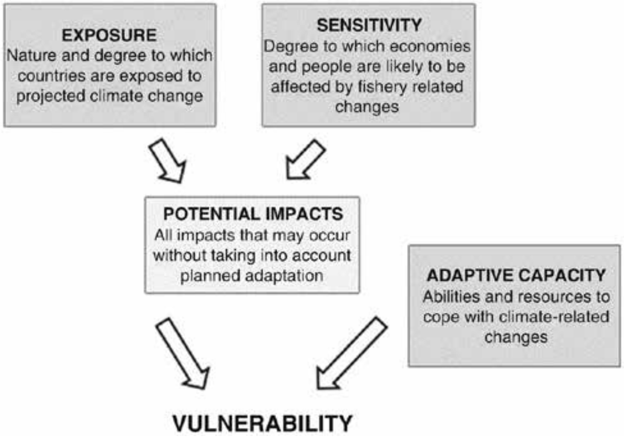
EXPOSURE
Nature and degree to which countries are exposed to projected climate change
SENSITIVITY
Degree to which economies and people are likely to be affected by fishery related changes
POTENTIAL IMPACTS
All impacts that may occur without taking into account planned adaptation
ADAPTIVE CAPACITY
Abilities and resources to cope with climate-related changes
VULNERABILITY

Figure 1. Vulnerability framework (Allison et al., 2009).

In the context of this research, the first component is the extent of exposure to the threats of climate change. The second component is sensitivity, relating to how likely economies and people are affected by changes in fishing practices. These two components further influence the impacts that can materialize without having adaptive strategies in place. The last component is the adaptive capacity, which entails the abilities and resources that SIS has to cope with climate-induced changes. These mentioned components make up the framework that then determines the extent of vulnerability.

With regards to the aforementioned framework, Aruba is significantly exposed to climate change-induced impacts. As highlighted by Monnereau et al. (2021), particular concerns are rising sea levels and temperatures, which pose substantial threats to coastal areas. These phenomena not only endanger coastal infrastructure but also directly affect local fishing communities, as evidenced by instances where boats collide with the docks, damaging wooden boats (Boekhoudt, 2024). Aruba's geographical characteristics, including its size, remoteness, and reliance on natural resources, are exacerbating the effects of climate change across the island. With its semi-arid climate, agricultural activities are severely limited, leading to a heavy reliance on food imports (Davila, 2017). As a result of high import levels, prices are high in Aruba, excluding sections of the population to afford healthy options. This further increases dependency on fishing as a crucial source of protein and sustenance.

However, Aruba's adaptive capacity, another component of this framework, is constrained by its slow response mechanisms, indicating a pressing need for more effective adaptation strategies. As the pace of climate change accelerates, the island's ability to cope with and adapt to these challenges must be enhanced to mitigate the adverse impacts on its communities and ecosystems. Considering these components, Aruba is vulnerable to the repercussions of climate change. Disproportions exist between how Aruba is being affected by climate change and how urgent their adaptation is. Understanding Aruba's vulnerability to climate change is of relevance for this research when understanding how vital fish is for communities, but at the same time, how important the implementation of the MPAs is.

3.3 Marine Park Areas

3.3.1 Aruba Marine Park Areas

The following part of this literature review will examine the 'Preliminary management plan' implemented by the Aruba National Park Foundation (FPNA) regarding Marine Protected Areas (MPAs) in Aruba, and compare this to Bonaire's National Marine Park. This will be done to comprehend the need for MPAs to protect Aruba's biodiversity.

The Aruba National Park Foundation is an independent authority that was officially established in 2000 (Parke Marino Aruba - Preliminary Management Plan, 2019-2021). The Arikok National Park makes up 20% of the island and aims to conserve and protect Aruba's natural and cultural heritages (Parke Marino Aruba - Preliminary Management Plan, 2019-2021). The Parke Marino Aruba (Marine Park Areas (MPAs)) were established on the 21st of December in 2018 and were brought under the management of the FPNA on the 16th of April in 2019 (Parke Marino Aruba - Preliminary Management Plan, 2019-2021). The FPNA will manage the MPAs on behalf of the Aruban government, whilst utilizing the Sustainable Development Goals and the concept of the Blue Economy. Through applying an ecosystem-based management (EBM) approach, the goals of the MPAs are to 'promote non-destructive and sustainable activities, minimizing negative human impact on the environment and identifying research priorities to benefit the conservation of natural ecosystems and their ecosystem services' (Parke Marino Aruba - Preliminary Management Plan, 2019-2021).

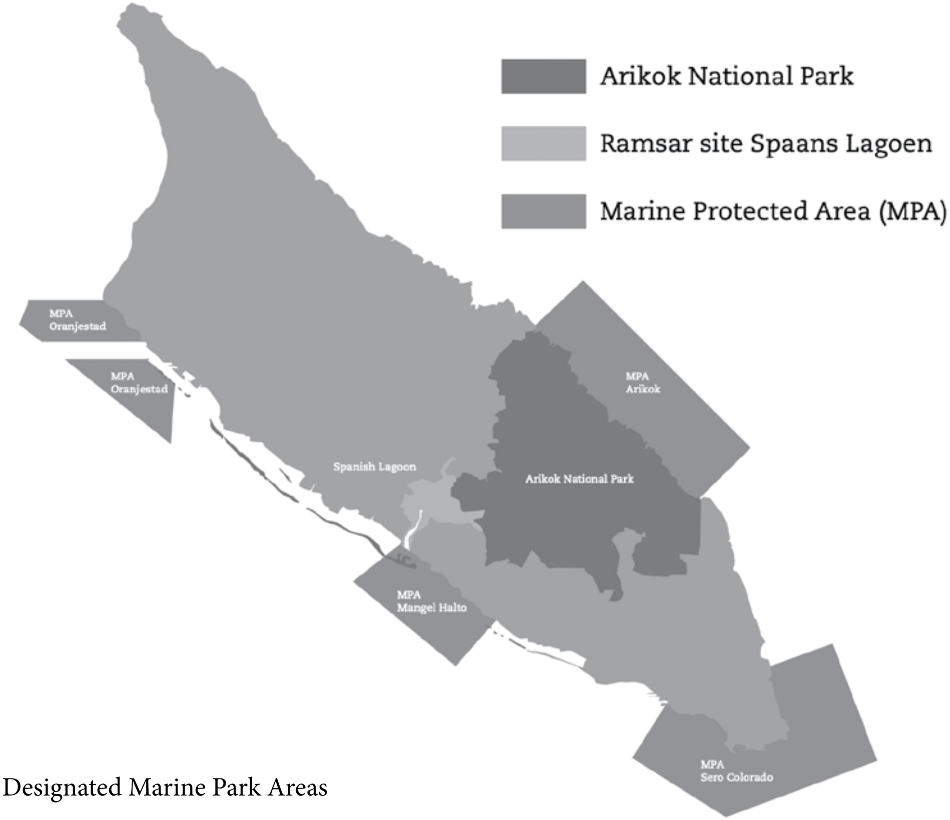

Figure 2: Aruba's Designated Marine Park Areas

The Parke Marino Aruba consists of four different MPA's, including MPA Arikok, MPA Sero Colorado, MPA Mangel Halto, and MPA Oranjestad Reef Islands (Parke Marino Aruba - Preliminary Management Plan, 2019-2021). Depending on the location, there will be different rules and regulations in place to accommodate the required protection that the area requires. Besides the location-specific regulations, the Preliminary Management Plan has established a set of five conservation strategies that apply to all of the MPAs. The first goal intends to increase marine research through available knowledge, practices, and scientific research to support the long-term management and conservation of resources. This is followed by the second goal, aiming to conserve and restore important marine ecosystems and processes. Promoting and engaging informative relationships with stakeholders and the community has been identified as the third goal. The fourth plan is to allow for sustainable use of the MPAs through non-destructive activities. And lastly, the fifth, targets capacity building, with an emphasis on financial security to foster these marine conservation efforts. Through these established goals, the marine parks will aim to restore and conserve Aruba's biodiversity, marine ecosystems, and ecological processes.

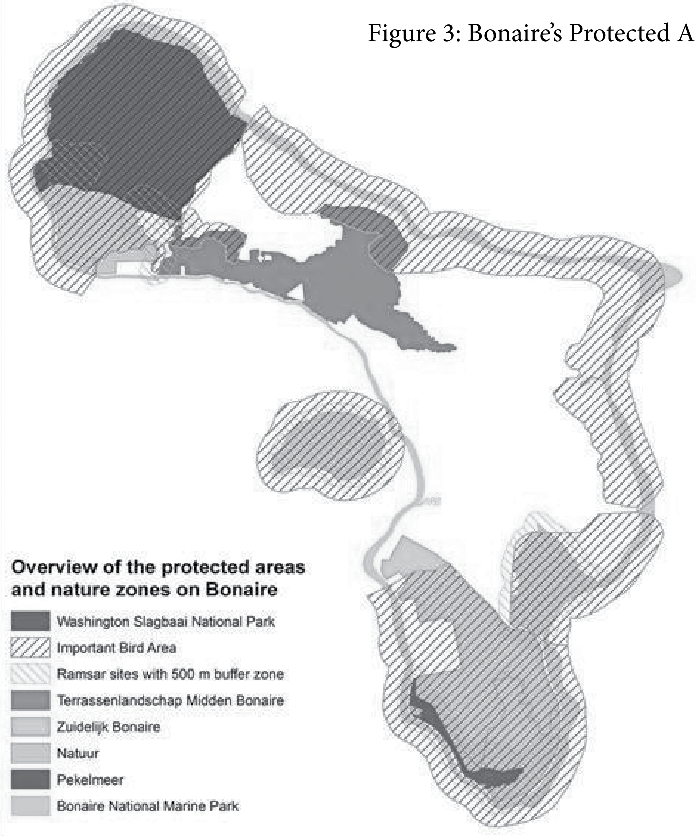

Figure 3: Bonaire's Protected Areas and Nature Zones

Overview of the protected areas and nature zones on Bonaire
Washington Slagbaai National Park
Important Bird Area
Ramsar sites with 500 m buffer zone
Terrassenlandschap Midden Bonaire
Zuidelijk Bonaire
Natuur
Pekelmeer
Bonaire National Marine Park

3.3.2 Bonaire Marine Park Areas

Bonaire, another ABC island, has established a national marine management plan spanning from 2022 to 2028 (De Meyer et al., 2022). Bonaire's marine park was established in 1979, making it the first marine park in the world (De Meyer et al., 2022). Since 2010 however, Bonaire has been challenged with a huge influx of tourists, the pace of their economic growth, and rapid population growth (De Meyer et al., 2022). These are causing stress to coastal developments and land conversion, requiring a difficult task in balancing nature conservation with economic development. Bonaire's management plan therefore centers around the following six main objectives. The first is optimizing the protection of key habitats and species, followed by improving sustainable recreation, encouraging sustainable fishing, controlling invasive species and diseases, supporting the restoration of key habitats and species, and lastly, influencing policy and legislation to improve park management (De Meyer et al., 2022). The identified objectives in Bonaire's management plan have been established in close cooperation with local stakeholders and also recognize the indigenous people of Bonaire, the Caquieto people.

Aruba's preliminary Management Plan for its Marine Protected Areas reflects a proactive stance towrads biodiversity preservation, akin to Bonaire's marine parks which similarly balance conservation with economic growth. Notably, Aruba intends to divide its MPAs into four distinct sections, while Bonaire has designated its entire coast as an MPA. This unified approach in Bonaire potentially offers advantages, mitigating fragmentation and regulatory confusion that might arise from Aruba's segmented strategy. The fragmented nature of Aruba's plan raises questions regarding the criteria for selecting these areas over others along the coast. Such fragmentation could lead to challenges in enforcement and monitoring, impacting fishing communities, tourists and regulatory bodies alike.

3.4 Conclusion

The review of the literature makes apparent that small island states face multifaceted challenges in pursuit of sustainable development. These challenges are causing detrimental impacts on the tourist, conservation, and fisheries sectors which are vital to the economic and social well-being of Aruba. The tourism industry is causing a lot of harm to their environmental prosperity, putting pressure on marine ecosystems, and habitats, accommodating the demand for coastal development, and so forth. The external climate conditions are in turn also affecting the tourism industry, which has detrimental effects on the economy of SIS. External shocks, including climate change, demand rapid transformations of Aruba's economy to achieve their Sustainable Development Goals (SDGs). The future implementation of Aruba's marine parks is a visible effort to achieve SDGs, namely by preserving and conserving Aruba's marine ecosystems. The comparison between Aruba's marine park management plan and that of Bonaire highlights the differences and potential repercussions that different types of implementations of MPAs can have.

The literature review emphasizes the urgent need for precise efforts at both local and global scales to support SIS in achieving their SDGs and adapting to global transformations. This requires a holistic approach that integrates environmental, economic, and social considerations, through inclusive collaboration. Through identifying and addressing the vulnerabilities and challenges that SIS faces, a path toward sustainable development can be paved.

4. Preliminary Results & Discussion

Based on the initial findings from a literature review and two interviews, several key insights have been developed. It is evident that Aruba's economic prosperity heavily relies on its tourism industry, a characteristic common to Small Island States. This reliance, however, exposes Aruba to the vulnerabilities associated with climate change, which not only impacts marine ecosystems but also the future of tourism itself, given the inherent relationship between climate and tourism. Paradoxically, tourism exacerbates climate patterns due to its unsustainable nature. In response to these challenges, environmental organizations in Aruba are proactively planning and implementing regulations aimed at protecting and enhancing biodiversity, particularly through the establishment of Marine Protected Areas (MPAs), targeting ecosystems like mangroves, shark nurseries, and coral reefs. These efforts align not only to safeguard Aruba's biodiversity but also with greater international objectives such as the Sustainable Development Goals.

However, amidst acknowledging the need for enhanced protection, it has also become evident that there is a disproportionate share of responsibility and accountability. Artisanal fishing communities, despite not being the primary contributors to environmental degradation, bear the direct consequences of environmental regulations, as their incomes depend on the well-being of marine ecosystems. This disproportionality is based on the economic significance that tourism contains, which makes it challenging for institutions to impose regulations that might adversely affect the tourism sector. Moreover, artisanal fishing communities face additional pressures from tourist-driven demands, such as the need to increase their catch to meet rising demand and prices, particularly from restaurants in need of daily and fresh fish catches. Despite possessing extensive knowledge of marine ecosystems and fishing practices, these communities find themselves marginalized in the decision-making process regarding marine protected regulations.

Consequently, artisanal fishing communities confront multifaceted vulnerabilities and challenges in times of global transformations, needing to deal with changes to the ocean as a result of climate change, adapting to the needs of tourists, and regulatory measures aimed at environmental protection. Despite their minimal contribution to environmental degradation, they find themselves disproportionately affected by regulatory interventions, highlighting the need for a more inclusive and interdisciplinary decision-making process to shape Aruba's marine conservation policies.

5. References

- Boekhoudt, B. Review of Current Fisheries Management Performance and Conservation Measures in the WECAF area. *FAO Fisheries and Aquaculture Technical Paper No. 587. Bridgetown*.
- Davila, I. C. (2017). Aruba Retail Report: A Growing Market for Consumer Products . *USD Foreign Agriculture Service*.
- De Meyer, K., MacRae, D.R., Raming, J., Eckrich, C. & van der Ploeg, J. (2022). *Bonaire National Marine Park Management Plan 2022-2028*. Kralendijk: STINAPA.
- Fundacion Parke Nacional Aruba (2020). Environmental Impact Report for Off Road Driving (ORD) in Parke Nacional Arikok. Fundacion Parke Nacional Aruba (FPNA), San Fuego 70, Aruba.
- Lenderking, H. L., Robinson, S., & Carlson, G. L. (2020). Climate change and food security in Caribbean small island developing states: challenges and strategies. *International Journal of Sustainable Development and World Ecology*, 28(3), 238–245. https://doi.org/10.1080/13504509.2020.1804477
- Monnereau, I., Mahon, R., McConney, P., Nurse, L., Turner, R., & Vallès, H. (2021). Fisheries sector Vulnerabilities to climate change in small island developing states. In *The world of small states* (pp. 233–255). https://doi.org/10.1007/978-3-030-82774-8_11
- Pantin, D. (1999). The challenge of sustainable development in small island developing states: case study on tourism in the Caribbean. *Natural Resources Forum*, 23(3), 221–233. https://doi.org/10.1111/j.1477-8947.1999.tb00911.x
- Parke Marino Aruba - Preliminary Management Plan 2019-2021 (2019). Fundacion Parke Nacional Aruba (FPNA), San Fuego 70, Aruba.
- Parke Marino Aruba - Policy Document - Managing Nature Conservation and High Impact Motorized Traffic (2020). Fundacion Parke Nacional Aruba (FPNA), San Fuego 70, Aruba.

- Sachs, J., Massa, I., Marinescu, S., & Lafortune, G. (2021). The Decade of Action and Small Island Developing States: Measuring and addressing SIDS'vulnerabilities to accelerate SDG progress'. *Sustainable Development Solutions Network*, 2021-07.
- Spencer, A. J. (2018). Climate change and the sustainable development of tourism within the Caribbean. In *Springer eBooks* (pp. 27–46). https://doi.org/10.1007/978-3-319-69581-5_2
- Stevens, M. (2019) Off-road driving and the ecosystem: An analysis of the impact on landscape functionality. *UAUCU Student Research Exchange Collected Papers 2019*
- *Sustainable development goals.* (n.d.). UNDP. https://www.undp.org/sustainable-development-goals
- Uitto, J., Kohlitz, J., & Todd, D. (2017). Evaluating sustainable development in SIDS-lesson from the Pacific and the Caribbean. *Evaluation for Agenda 2030: Providing Evidence on Progress and Sustainability*

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It is simply a place and life I will never forget.

Aruba began to feel like home once I started recognising people while out and about. The university began to feel like home when I had my favourite spots to sit and get in some study hours. And the roads began to feel like home once I figured out which roundabout led to which beach! Having already lived in a few countries, I have come to realise that the feeling of home comes from the people you are surrounded by and the routine you make but no feeling of home has ever come this quick for me. My routine became sunset beach dinners (typically cold curry), hikes in Arikok National Park, monthly beach tennis tournaments and daily swims in the ocean as part of a mission with my best friend Claire! I finally took up sketching again, a hobby that I lost inspiration in but was just surrounded by in Aruba. Every corner you turn in Aruba has an avenue for exploration, so much so that I had a list of potential thesis ideas within a couple of weeks of being on the island. Arriving a month earlier than the beginning of the course, Claire and I were thrown into the deep end of island life and had a lot of time to build up a mental map of Aruba from our experiences with an Aruban family. This shifted into a map as a student living in Aruba, finally meeting other young people after what felt like forever. Now, at then end of this course and with a month left in Aruba, it is simply a place and life I will never forget. Some highlights include spontaneous sunset swims, lighting parades, learning to kitesurf, dancing bachata on saturday nights, winning the beach tennis tournament with Claire and meeting so many amazing people on the island.

I want to thank everyone who supported both here in Aruba and back home through my journey. I want to thank Eric and Jocelyn for their encouragement to be curious, my supervisor Brandon for his guidance and the people on the island who inspired my research and the final product. The friends I made on the island who pushed me to be the best version of myself. Lastly, to Claire, who I could not have imagined this process without, thank you for being there for me through it all.

Herding Profits: Factors affecting Goat Commercialisation amidst Grazing Constraints in Aruba

Ella-Anika Blom

1. Introduction

In many Small Island States (SIS), the potential for goat farming and animal husbandry to significantly contribute to food security is often overlooked, despite being a powerful avenue for developing sustainable rural livelihoods and enhancing the economic independence of rural communities. Aruba, located in the Southern Caribbean Sea off the coast of Venezuela, has a hot desert climate making agricultural production a more complex undertaking (Rijks Geologische Dienst, 2019). Goats however possess high adaptability to harsh environments and limited resources, making them an ideal livestock choice for island communities facing challenges including land scarcity and climate variability. In addition, goats offer valuable animal protein at a reduced cost by utilising marginal land typically unsuitable for other livestock like sheep and cows. This is attributed to their capacity to graze across a diverse range of terrain types (Silanikove, 2000).

The history of goats on Aruba is intertwined with the island's colonisation and development over the centuries. Goats were introduced to Aruba by early Spanish explorers and settlers during the colonial period, which began in the early 16th century (Van Buurt & Debrot, 2012). These early settlers brought goats along as a source of food, milk, and leather, as they were well-suited to the island's arid environment and rugged terrain. The abundance of goats on the island led to Aruba being dubbed a 'goat island' by the West India Company, owing to the large number of goats roaming freely. Throughout Aruba's history, goats played a vital role in the livelihoods of its inhabitants. They provided a reliable source of meat, milk, and other dairy products, sustaining the island's population, particularly during periods of scarcity or hardship (Veerbeek, 2016). Additionally, goats were valued for their hides (skin) and served as a form of currency in trade with neighbouring islands and mainland territories. However, the unchecked proliferation of goats on Aruba also posed challenges. As feral populations grew, they began to exert pressure on the island's fragile ecosystem through their extensive grazing and trampling of the natural area, especially along the north coast of the island (Rosa García et al., 2012). This has prompted questions, both in Aruba and other Caribbean islands, on how best to manage the feral population and the environmental degradation that follows their tracks.

It is an ongoing debate of the National Park Foundation (Fundacion Parke Nacional Aruba) on how to manage the goat population. Currently, it is estimated there are around 43 goats per 1km2 which amounts to 1465 feral goats across Arikok National Park (Veerbeek, 2016). In Bonaire and Curacao, where goat populations are similarly abundant, the National Park authorities have implemented goat culling of feral goats to mitigate the extent of land degradation and vegetation loss (Debrot, 2016). In Aruba, however, this has not yet been implemented with the primary focus being on the goats belonging to herders rather than feral goats in the National Park. A restriction aimed at farmers would affect goat herders who let their goats roam free in the park to graze during the day, bringing them back to their own plots of land for the night, a practice rooted in Aruban tradition (Veerbeek, 2016). The farmers would have to adapt their farming practices from extensive goat farming to intensive goat farming. Extensive goat farming allows goats to graze freely on large pasture areas with minimal supplementary feed and management. In contrast, intensive goat farming confines goats to smaller spaces and provides them with controlled diets, requiring more intensive management and investment in infrastructure. An increase in intensive farming will greatly affect the supply and growth of the commercial goat market on Aruba.

Currently, in comparison to the volume of meat that is imported to Aruba yearly, locally slaughtered meat amounts to less than 0.01% of consumption in the formal market exemplifying how minimal formal goat commercialisation is on Aruba (Polaszek et al., 2018). While literature concerning the informal sector is limited, an IMF study examining the informal economy in Latin America and the Caribbean reveals that, on average, the informal sector contributes approximately 26 percent to the GDP of selected SIS (International Labour Organisation, 2017). However, jumping from a renowned 'goat island' to an island that imports a significant amount of its meat raises questions on what is behind farmers' choice to participate in goat production.

This paper tries to answer the following questions: firstly identifying these factors that affect goat commercialisation in Aruba and secondly, to what extent a goat restriction policy in the national park will affect commercialisation and market participation of goat farmers. The paper is set out as follows: the next section defines the research goal, followed by methodology. Then comes the literature review of goat farming and commercialisation in Aruba and other rural areas or Small Island States and lastly a conclusion of findings.

1.1. Research Goal

This research investigates the choices farmers make regarding engaging in goat selling and commercialisation, as well as their selection between informal and formal market channels. Commercialisation involves transitioning from subsistence farming to a market-oriented approach aimed at maximising profits. Therefore, it has the potential to transform smallholder goat farmers by shifting production practices from consumption-oriented to market-oriented strategies, thus fostering economic development through increased income. This research aims to identify the factors influencing farmers' decisions to engage in the goat market and determine the level of goat commercialisation within the study area. Additionally, it is vital to assess how limiting goat farmers' access to Arikok National Park affects the degree of goat commercialisation. Restrictions on goat grazing in the park could significantly affect local goat farmers. As Arikok National Park serves as a crucial grazing area for goats, limitations on their access could disrupt traditional grazing patterns and reduce available grazing land for farmers. Consequently, this restriction could influence farmers' decisions regarding goat commercialisation. Understanding the impact of this restriction is essential for comprehensively assessing the various factors influencing farmers' decisions regarding goat production and commercialisation.

2. Methodology

2.1. Description of study area

This study was carried out across Aruba, situated in the southern Caribbean Sea, located about 29 kilometres north of the Venezuelan coast. It is one of the four constituent countries that form the Kingdom of the Netherlands and covers an area of approximately 180km^2 and a population size of around 120,000 people (CIA, 2023). Arikok National Park, located along the east coast, was established in 2000 and covers around 25% of the land area on the island (Parke Nacional Aruba, 2023).

2.2. Data collection

For this paper, a thorough literature review and exploratory interviews were carried out. While the literature primarily concentrated on goat farming in Aruba and other Caribbean islands, it was noted that there wasn't a substantial amount available. Consequently, the scope of the study was broadened to encompass other Small Island States and the dynamics present in goat farming within those regions. Multiple exploratory interviews were carried out with stakeholders from the National Park Foundation, and the Department of Agriculture Santa Rosa as well as members of the goat farming community. This allowed for the acquisition of diverse perspectives on the island's conservation, food security, and agricultural capacity, themes which underpin this research. Additionally, obtaining context-specific analyses of goat farming from interviews proved highly valuable, complementing the literature review that covered the intricacies of goat farming in SIS.

2.3. Methodology proposal for further study

This research is the foundation of a broader study for which it is proposed that further interviews and a survey are conducted along with statistical analysis of the survey results. Since not all farmers on the island are registered with Santa Rosa, the goal of the broader study research is to speak to as many farmers as possible on the island. Through snowball sampling and knowledge of the Agricultural Department, a minimum sample of 15 farmers will serve as the initial goal. Data will be collected through an anonymous structured survey sent to goat farmers via Facebook and Whatsapp as well as semi-structured face-to-face interviews with the farmers willing to meet. A Probit and Tobit model will examine factors influencing goat commercialisation. The Probit model assesses participation probability based on farmer demographics, farm characteristics, market access, and profitability perceptions (Aldrich & Nelson, 1984). The Tobit model analyses the extent of commercialization among participating farmers, measuring from zero to one (McDonald & Moffitt, 1980). Both models use similar independent variables: age, education, livestock count, market channels, farmer association membership, and land size.

3. Literature Review

This literature review delves into various aspects of goat farming in Aruba and its implications for the island's agricultural landscape, conservation efforts, and food security. It begins by exploring the unique characteristics of the Aruban goat market, shaped by the island's geography, climate, and cultural practices. Aruba's landscape, characterised by arid and semi-arid regions with sparse vegetation, provides an ideal environment for goat rearing (Veerbeek, 2016). Subsequently, the review delves into the conservation challenges posed by goat grazing, particularly in Arikok National Park, and examines goat management strategies implemented in other Caribbean islands. Factors affecting goat farming in Small Island States are discussed, highlighting constraints such as limited land availability and lack of market access. Cultural factors also play a significant role, influencing the informal nature of the goat market in Aruba. Furthermore, the review addresses the role of goat farming in enhancing food security, emphasising the need for local production to reduce dependence on imports and mitigate vulnerabilities in the food supply chain. By exploring these themes, this review aims to provide insights into the dynamics of goat farming in Aruba and its implications for sustainable development and food sovereignty in SIS.

3.1. The Aruban goat market

In Aruba, the goat market currently operates within a framework that is predominantly informal and characterised by low levels of organisation. The informal nature of the market stems from various factors including historical practices, cultural norms, and economic conditions. In 2022, within the formal market, an estimated value of $59 million of meat and edible offal was imported to Aruba in comparison to an estimated $12,000 of meat exported out of Aruba (UN Comtrade Database, 2024). In comparison to the volume of meat that is yearly imported to Aruba, locally slaughtered meat amounts to less than 0.01% (Schep, 2017). The stark contrast between the significant value of goat meat imports to Aruba and the minimal amount exported underscores the island's heavy reliance on external sources to meet domestic demand. The island's official population is relatively small, numbering around 120,000 residents, excluding the significant proportion of tourists visiting annually and an estimated 17,000 undocumented refugees (HIAS, 2024; The World Bank, 2022). Of the $59 million imported meat and offal an estimated $1.32 million was goat and sheep meat making it a much smaller part than chicken and beef (OEC, 2022). However, despite its potential, the local goat market has not undergone significant formalisation or modernisation processes.

The concept of smallholder commercialisation, central to understanding the dynamics of agricultural households' engagement with markets, is crucial for assessing the degree to which these households are oriented towards profit-making activities. Assessing the level of smallholder commercialisation enables comparisons among households based on their extent of engagement with markets, encompassing production, marketing, and consumption decisions (Jaleta et al., 2009). This assessment also facilitates the analysis of factors influencing commercialisation. In essence, smallholder commercialisation signifies the strength of the linkage between farm households and markets, driven by the desire to generate profit. This linkage encompasses interactions in output and input markets, involving selling, buying, or both. Additionally, commercialisation can be viewed as a dynamic process, reflecting the pace at which households transition towards market-oriented activities over time. In various contexts, commercialisation can be defined differently, but in a SIS like Aruba, it can be understood best as activities aimed at financial gain (Guell et al., 2022).

3.2. Conservation

Most goat farmers are based in the rural areas of the island where the goats depend on natural foraging, especially in Arikok National Park. However this is a big issue for the biodiversity of the national park as the goats both graze and trample vast areas of the park very quickly and cause a lot of ecological damage (Verbeek, 2016). As a result of this the Fundacion Parke Nacional Aruba (FPNA), is potentially implementing a policy to ban the free grazing of goats in Arikok National Park (T. Lopez, personal communication, January 28, 2024). As this conservation area covers roughly 25% of the island, the impact this will have on goat farming will be widespread and hard to predict (Parke Nacional Aruba, 2023).

Across many other Caribbean islands, efforts have been made to reduce the impact of feral goats on the vegetation and ecosystems. Some examples include Puerto Rico where various conservation organisations and government agencies have initiated goat control and eradication programs in ecologically sensitive areas, including El Yunque National Forest (Hunter, 2023). Furthermore, other Caribbean islands within the Kingdom of the Netherlands such as Saba, Bonaire and Curacao implemented goat management strategies to protect the ecosystem. In Saba, the Goat Control Project aimed to remove 3,000 to 5,000 feral goats from the island by local hunters. For this the distinction was made between feral goats and goats owned by farmers which make up a much smaller proportion (Public Entity Saba, 2024).

3.3. Factors affecting goat farming in Small Island States

Agricultural productivity in Small Island States is influenced by a unique multitude of factors such as limited land availability, water scarcity and dependency on imports (FAO, 2019). The capacity to produce large amounts of products for export purposes to other countries is minimal. There is however an opportunity to provide for the local population on a small scale. In SIS, smallholder goat farmers' productivity is impacted by factors such as lack of information, lack of market access, and weak infrastructure (Ntshangase et al., 2023). These factors present challenges to enhancing smallholder production, resulting in difficulties for smallholder producers in commercialising their output. The primary hurdle in achieving commercialisation lies in enabling smallholders to access and engage in markets which results in the informal nature of goat farming in many SIS such as Aruba (Sharma et al., 2012). There is a high prevalence of small-scale goat farmers who engage in subsistence or semi-subsistence farming practices and do not have the knowledge of integrating into the formal market. These farmers often raise goats as a supplementary source of income rather than as their primary livelihood. As a result, they may not have the resources or incentives to invest in formal market channels such as selling to enterprises. In some cases, farmers in SIS express concerns about taxation. This fear may stem from uncertainty about how taxation policies could impact their livelihoods, particularly in areas where formal regulations are not well-established or where there's a perception of limited government support for agricultural activities. However, the extent to which farmers fear taxation can vary depending on factors such as local economic conditions, government policies, and individual circumstances ((Bird, 1974; OECD, 2020).

Cultural factors also play a role in shaping the informal goat market in Aruba as most people consume goat meat on special occasions. Goats hold cultural significance in Aruban society, being used in traditional culinary dishes and cultural celebrations with the peak selling of goats occurring in November and December in preparation for the holidays (Kalm, 1975). Traditional culinary dishes include the cabrito stoba, a savoury goat stew served with rice and other side dishes. This cultural attachment to goats and goat products may influence how they are traded and valued within the community, often favouring informal exchanges over formalised market transactions (Mary et al., 2016). This could be because informal trading relies on a network of family, friends and neighbours facilitated by trust and familiarity, which fosters a sense of community, exactly what culturally significant products promote.

Additionally, the absence of well-established infrastructure and regulatory frameworks for the goat industry contributes to the informal nature of the market. The lack of formal processing facilities, quality standards, and marketing mechanisms makes it challenging for goat farmers to access formal markets as official purchasers of the products will want guarantees of quantity, feed, quality and speed. Consequently, many farmers opt to sell their goats directly to consumers or through informal networks rather than navigating the complexities of formal market channels (Homann et al., 2007). The absence of regulatory frameworks in most SIS, leaves goat farmers uncertain about their rights and obligations within the industry. The lack of enforceable regulations regarding production practices, animal welfare standards, and product labelling further complicates efforts to access formal markets. In the absence of clear guidelines, farmers may be hesitant to invest in upgrading their operations or adopting new technologies, fearing potential repercussions or legal uncertainties. This transfers into the weak connection between local agricultural production and the hotel and tourism industry. In Aruba, similar to many other SIS, tourism makes up over 85% of the economy and over 90% of local employment depends either directly or indirectly on tourism (Davila, 2019). The main issue with this connection is that hotels and restaurants have quite strict regulations on the products they buy including guidelines on the feed the animals were provided, the way the animal was kept and slaughtered and the consistency of supply. This makes it difficult for small-scale farmers to be able to supply to the formal market and in turn increase the size of the informal market. Increased regulation and support to small-scale farmers in Aruba could lead to increased access to the formal market and as a result contribute to economic diversification (Thomas-Francois et al., 2016).

The expertise and knowledge of farmers local to SIS are invaluable; however, transitioning from subsistence extensive farming, reliant on vast national park pastures, to small-scale intensive farming demands a distinct skill set and understanding (Achmad et al., 2022). The island's rapid urban development is already forcing farmers to adjust their grazing practices and contend with urban challenges such as theft, road traffic accidents and the resulting medical attention required, which were not prevalent in rural settings. Intensive farming necessitates increased labour input, especially in managing confined spaces and maintaining higher stocking densities. In terms of land space, if farmers previously relied on grazing lands beyond their property, transitioning to intensive farming requires acquiring or reallocating land resources. Moreover, a shift in strategy is imperative, as intensive farming requires new attention to factors such as feed formulation, waste management, and disease prevention, contrasting with the more extensive and naturalistic approach of traditional farming methods. Therefore, as SIS undergo rapid development and urbanisation, farmers must adapt their practices and acquire new skills to ensure the sustainability and viability of their agricultural practices in evolving landscapes.

There is a desire for many goat farmers to learn more about commercialisation as shown by their involvement in a workshop ran by Edward Berben of the Department of Agriculture, Santa Rosa, in 2023 called 'Commercial goat and sheep management' (Coster, 2023). This reflects the island-wide push for increased agricultural production and a desire from locals to learn more about their potential to produce for a formal market.

3.4. Food security

Limited information available about smallholder goat farmers or goat production in general is available on the island as only recently goat farmers have begun registering with the Aruban Department of Agriculture. Goats are well-suited for transitioning from subsistence to commercial farming due to their resilience to disease, internal parasites, and adaptability to arid habitats like the dry conditions in Aruba. This makes goats a more productive livestock option over cows and sheep for providing a more food-secure source of meat in SIS. Additionally, the high rates of twins and even triplets in goat reproduction, which vary between different breeds, make them a highly productive livestock option. On average, a doe can reproduce every 8 months, with a gestation period of 5 months and minimum 3 months of recovery (Marete , 2020). There are many goat breeds present on the island with the more common ones being Boer, Nubians and Dorpers, with origins ranging from countries in Africa to Alpine countries. By breeding them together to create mixed breeds, the strengths of certain breeds can be combined to breed goats that are best suited to the Aruban climate and have the highest productive value (Simões & Gutiérrez, 2017). While certain breeds are more suitable for extensive or intensive farming, this distinction is not currently fully implemented in Aruba. However, studies conducted in other countries, such as Jordan which is also an arid environment, have demonstrated the effectiveness of this practice (Al-Khaza'leh et al., 2016).

Animal husbandry, such as the expansion of goat commercialisation, plays a crucial role in strengthening food security in Aruba, a nation heavily reliant on imports for sustenance. The second Sustainable Development Goal 'Zero Hunger' encompasses the importance of this focusing on ending hunger, achieving food security and promoting sustainable agricultural practices (United Nations, 2023). The island's near total dependence on imported food, including goat meat products, exposes it to vulnerabilities within its food supply chain. These vulnerabilities may arise from external factors such as global market fluctuations, transportation disruptions, and supply chain interruptions. By prioritising the development of local animal husbandry practices, especially in goat farming, Aruba can mitigate these risks and enhance its food self-sufficiency. As discussed in the World Bank report "Building Aruba's Food Security during Covid and Beyond', there are two pillars onto which food security can be grounded: 1) commercial-scale agricultural expansion and 2) wide-spread micro-scale residential production (The World Bank, 2022a). Animal husbandry and the goat production market can come under both pillars when it demonstrates compatibility of operating scale with the demands on the natural environment. This encompasses the shift from extensive to intensive farming, confining animal husbandry to smaller plots of land in order to minimise damage to the environment. Producing more goat meat locally allows Aruba to reduce its reliance on imports, thereby improving resilience to external shocks and ensuring a more stable and secure food supply for its population. This shift towards local production stimulates economic growth by creating opportunities for local farmers and bolstering the agricultural sector, helping to diversify the economy away from direct tourism. Furthermore, investing in animal husbandry and goat commercialisation aligns with broader sustainability goals, such as reducing carbon emissions associated with food transportation and diversifying the economy and supporting local businesses (SDGs 8 and 12) (United Nations, 2023).

4. Conclusion

This paper provides an overview of the complexities of agricultural production in Small Island States (SIS). Within the intricate interplay of economy, ecology, and society, satisfying the needs of all groups proves challenging. The findings presented highlight the crucial role of goat farming in Aruba's agricultural landscape, deeply intertwined with the island's geography, climate, and cultural heritage. Despite the predominance of informal operations, Aruba's heavy reliance on imported goat meat underscores the urgency for a more formalised and modernised goat industry. Challenges such as limited land availability, water scarcity, and import dependencies further hinder agricultural productivity in SIS like Aruba. The transition from subsistence to commercial goat farming necessitates specific skills and knowledge, particularly amidst rapid urban development. However, efforts to formalise the goat industry face obstacles due to the lack of regulatory frameworks and infrastructure, perpetuating the informal market nature. Cultural significance, limited market access, and insufficient knowledge complicate efforts to enhance commercialisation and productivity among smallholder goat farmers. Despite these challenges, there is a growing interest among farmers in learning more about commercialisation, indicating potential for sector development. To address food security concerns, prioritising local animal husbandry practices, especially goat farming, is crucial to reducing import reliance and enhancing self-sufficiency. Investing in sustainable agriculture aligns with broader sustainability goals, fostering economic growth, supporting local businesses, and mitigating environmental impact, thereby ensuring a more resilient and secure food supply for Aruba's population..

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References

- Achmad, B., Sanudin, Siarudin, M., Widiyanto, A., Diniyati, D., Sudomo, A., Hani, A., Fauziyah, E., Suhaendah, E., Widyaningsih, T. S., Handayani, W., Maharani, D., Suhartono, Palmolina, M., Swestiani, D., Budi Santoso Sulistiadi, H., Winara, A., Nur, Y. H., Diana, M., & Gartika, D. (2022). Traditional Subsistence Farming of Smallholder Agroforestry Systems in Indonesia: A Review. Sustainability, 14(14), 8631. https://doi.org/10.3390/su14148631
- Al-Khaza'leh, J., Reiber, C., & Ogutu, J. O. (2016). Goat Breeds Performance under Different Farming Systems and Conditions of Water Availability in the Karak Governorate , Jordan = أداء السلالات الماعز تحت نظم المزارعة المختلفة و ظروف توافر المياه في محافظة الكرك ، الأردن. *Jordan Journal of Agricultural Sciences, 12*(2), 441–458. https://doi.org/10.12816/0030030
- Aldrich, J. H., & Nelson, F. D. (1984). Linear Probability, Logit, and Probit Models. *In Google Books*. SAGE. https://books.google.com/books?hl=en&lr=&id=z0tmctgE1OYC&oi=fnd&pg=IA3&dq=probit+model&ots=rvIF_L-sb_&sig=EwltNTsi3vu1Ce3i2pdM6timiyg#v=onepage&q=probit%20model&f=false
- Bird, R. M. (1974). Agricultural taxation in developing countries: A discussion of the policy issues in designing an effective system of agricultural taxation. *Finance & Development, 11*(003). https://doi.org/10.5089/9781616353186.022.A010
- CIA. (2023). *Country Summary*. CIA.gov; Central Intelligence Agency. https://www.cia.gov/the-world-factbook/countries/aruba/summaries/
- Coster, R. (2023, April 8). *Every goat is a vote*. Bati Bleki by Rona Coster. https://batibleki.wheninaruba.com/every-goat-is-a-vote/
- Davila, I. C. (2019). *Aruba Retail Report: A Growing Market for Consumer Products*. USDA Foreign Agricultural Service.
- Debrot, A. O. (2016). *Goat culling project Slagbaai,*

Bonaire: 1 st Year Progress Report, Field Assessment and Key Recommendations. https://www.researchgate.net/publication/342657917_Goat_culling_project_Slagbaai_Bonaire_1_st_Year_Progress_Report_Field_Assessment_and_Key_Recommendations

- FAO. (2019). *FAO'S WORK WITH SMALL ISLAND DEVELOPING STATES*. https://www.fao.org/3/ca5170en/ca5170en.pdf
- Guell, C., Brown, C. R., Navunicagi, O. W., Iese, V., Badrie, N., Wairiu, M., Saint Ville, A., Unwin, N., Kiran, S., Samuels, T. A., Hambleton, I., Tukuitonga, C., Donato-Hunt, C., Kroll, F., Nugent, R., Forouhi, N. G., & Benjamin-Neelon, S. (2022). Perspectives on strengthening local food systems in Small Island Developing States. *Food Security*, 14, 1227–1240. Springer Link. https://doi.org/10.1007/s12571-022-01281-0
- HIAS. (2024). *Support for refugees in Aruba*. HIAS. https://hias.org/where/aruba/
- Homann, S., van Rooyen, A., Moyo, T., & Nengomasha, Z. (2007). *International Crops Research Institute for the Semi-Arid Tropics ® Goat production and marketing: Baseline information for semi-arid Zimbabwe*. https://core.ac.uk/download/pdf/211008795.pdf
- Hunter, B. (2023). *FINDING OF NO SIGNIFICANT IMPACT AND DECISION TO*. https://www.fws.gov/sites/default/files/documents/Decision%20and%20FONSI_Culebrita_LP_PF_DRAFTV2_SP_Housh_Pam_AMR%20%281%29.pdf
- International Labour Organisation. (2017). *Informality and economic units in the Caribbean*.
- Jaleta, M., Gebremedhin, B., & Hoekstra, D. (2009). *Smallholder commercialization: Processes, determinants and impact*. https://www.marketlinks.org/sites/default/files/resource/files/ILRI%20-%20Smallholder%20Commercialization%20Processes.pdf
- Kalm, F. (1975). THE DISPERSIVE AND REINTEGRATING NATURE OF POPULATION SEGMENTS OF A THIRDWORLD SOCIETY: ARUBA, NETHERLANDS ANTILLES. - ProQuest. In *www.proquest.com*. https://www.proquest.com/openview/2e8bbc72751caecb20bfee8d0febbf72/1?pq-origsite=gscholar&cbl=18750&diss=y
- Lopez, T. (2024, January 28). *Goat grazing in Arikok National Park* (E.-A. Blom, Interviewer) [Personal communication].
- Marete , A. G. (2020). *Goats (new with animal welfare information) | Infonet Biovision Home*. Infonet-Biovision.org. https://infonet-biovision.org/animal-species/goats-new-animal-welfare-information
- Mary, K., Davidson-Hunt, I. J., Annette Aurélie Desmarais, & Hudson, I. (2016). *Creole Hens and Ranga-Ranga: Campesino Foodways and Biocultural Resource-Based Development in the Central Valley of Tarija, Bolivia*. 6(3), 41–41. https://doi.org/10.3390/agriculture6030041
- Maureen Ntshangase, Z., Moyo, B., Sanelise, T., k Van Nieker, J., & Misery, S. (2023). Factors Affecting Household Goat Farmers' Market Participation and the Extent of Commercialization. In *Goat Science: Environment, Health and Economy*. BoD – Books on Demand.
- McDonald, J. F., & Moffitt, R. A. (1980). The Uses of Tobit Analysis. *The Review of Economics and Statistics*, 62(2), 318–321. https://doi.org/10.2307/1924766
- OEC. (2022). *Sheep and Goat Meat in Aruba*. The Observatory of Economic Complexity. https://oec.world/en/profile/bilateral-product/sheep-and-goat-meat/reporter/abw
- OECD. (2020). *Taxation in Agriculture*. OECD Publishing. https://doi.org/10.1787/073bdf99-en
- Parke Nacional Aruba. (2023). *Aruba National Park Foundation*. Aruba National Park. https://www.arubanationalpark.org/main/
- Polaszek, T., Lacle, F., van Beukering, P., & Wolfs, E. (2018). *The Economics of Ecosystems and Biodiversity, Aruba*.
- Rijks Geologische Dienst. (2019, December 12).

Geology map of Aruba | Dutch Caribbean Biodiversity Database. Www.dcbd.nl. https://www.dcbd.nl/document/geology-map-aruba-0

- Rosa García, R., Celaya, R., García, U., & Osoro, K. (2012). Goat grazing, its interactions with other herbivores and biodiversity conservation issues. *Small Ruminant Research*, 107(2-3), 49–64. https://doi.org/10.1016/j.smallrumres.2012.03.021
- Saba, P. E. (2024, January 12). *Greening of Saba progresses as livestock control project continues; Dutch hunters join forces for accelerated goat removal*. Public Entity Saba. https://www.sabagov.com/post/greening-of-saba-progresses-as-livestock-control-project-continues-dutch-hunters-join-forces-for-ac
- Sharma, V., Jain, D., & De, S. (2012). *Managing agricultural commercialization for inclusive growth in South Asia*. GDN Agriculture Policy Series.
- Silanikove, N. (2000, March). *The physiological basis of adaptation in goats to harsh environments | Request PDF*. ResearchGate. https://www.researchgate.net/publication/236646664_The_physiological_basis_of_adaptation_in_goats_to_harsh_environments
- Simões, J., & Gutiérrez, C. (2017). *Sustainable Goat Production in Adverse Environments: Volume I*. https://www.boerboksa.co.za/Publications/Articles/New/Sustainable%20Goat%20Production%20in%20Adverse%20Environments%20Volume%201.pdf
- Stijn Schep. (2017, June 8). TEEB *Aruba - The Economics of Ecosystems and Biodiversity*. Wolfscompany. https://www.wolfscompany.com/project/teeb-aruba-the-economics-of-ecosystems-and-biodiversity/
- The World Bank. (2022a). Building Aruba's Food Security During the COVID-19 Pandemic and Beyond | GFDRR. In *www.gfdrr.org*. https://www.gfdrr.org/en/publication/building-arubas-food-security-during-covid-19-pandemic-and-beyond
- The World Bank. (2022b). *Population, total - Aruba | Data*. Data.worldbank.org. https://data.worldbank.org/indicator/SP.POP.TOTL?locations=AW
- Thomas-Francois, K., Von Massow, M., & Joppe, M. (2016). Strengthening Farmers–Hotel Supply Chain Relationships: A Service Management Approach. *Tourism Planning & Development*, *14*(2), 198–219. https://doi.org/10.1080/21568316.2016.1204359
- UN Comtrade Database. (2024). *Aruba Exports of meat and edible meat offal*. Un.org. https://comtradeplus.un.org/TradeFlow?Frequency=A&Flows=X&CommodityCodes=02&Partners=0&Reporters=533&period=2023&AggregateBy=none&BreakdownMode=plus
- United Nations. (2023). *Goal 2: Zero Hunger - United Nations Sustainable Development*. United Nations Sustainable Development; United Nations. https://www.un.org/sustainabledevelopment/hunger/
- Van Buurt, G., & Debrot, A. (2012). *Exotic and invasive terrestrial and freshwater animal species in the Dutch Caribbean*. https://www.dcbd.nl/sites/default/files/documents/C001-12%2520invasive%2520animals%2520Dutch%2520Caribb.pdf
- Veerbeek, B. (2016). *"Goats or no goats" The influence of goats on soil erosion and vegetation in Arikok National Park, Aruba. MSc thesis by Babette Veerbeek Soil Physics and Land Management Group.* https://www.dcbd.nl/sites/default/files/documents/Veerbeek%2C%20B.%20%282016%29%20Goats%20Aruba%20impact.pdf

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From OGM Studies to a SISSTEM Course.

I am enrolled in the Organization, Governance, and Management (OGM) program, which differs significantly from SISSTEM. When Eric introduced the UAUCU program to our class, I felt compelled to participate. Since joining OGM, my interest in sustainability has grown steadily, especially during my second year when I took the Small Island Developing States (SIDS) course. Engaging with articles and working on a policy memo about sustainable tourism during this course made me realize my passion for sustainability. Since my thesis is about medical waste management in Aruba, I thought it would fit right in with this course.

Reflecting on the past few weeks, I am truly pleased with my decision to join this course. I have gained valuable knowledge, connected with students from diverse backgrounds and cultures, and engaged in various activities beyond just attending classes. I particularly enjoyed our class discussions, where we explored different perspectives on various issues and challenges. Moreover, I valued gaining insights into sustainability challenges in Small Island States (SIS), particularly through lectures like Diego Acevedo's discussion on resources and the circular economy, and Ghislaine Nicolaas's presentation on global, local, and glocal sustainable development challenges in SIS.

One of the highlights for me was the field trip during the first week, where we visited locations like Bubali Plas. As an Aruban, I discovered a few eye-opening facts at Bubali Plas, that I hadn't realized before. Realizing the seriousness of issues like the condition of the sewage system served as a stark reminder of the pressing need for immediate action. Additionally, I thought it was great that we had guest speakers because they brought different perspectives from the field which added depth to our discussions and offered valuable insights. It was also inspiring to witness the UCU/

GSS students actively engaging in problem-solving, and offering innovative solutions for Aruba.

This experience was truly captivating and enlightening and it has clarified my path for future master's studies and potential career directions.

Navigating the Path to Sustainable Medical Waste Management in Aruba: Unveiling Challenges and Solutions

Francine Pieternella

1. Introduction

People typically envision everyday items such as plastic, paper, glass, and food when considering waste. However, the topic of medical waste, including its disposal and management, often goes unnoticed. Medical waste is a subset of waste produced in healthcare facilities, including hospitals, doctor's offices, dentist offices, blood banks, veterinary hospitals/clinics, and medical research centers and laboratories (Medical Waste, 2022). Due to its significant effects on the environment and public health, waste management has become essential, especially in healthcare settings. Poor waste management can lead to contamination of the air, water, and soil, which harms both the environment and human health. Furthermore, any individual who comes into contact with hazardous waste, whether inside the facility where it is generated or outside, will be exposed if not managed correctly (IETC et al., 2021). The development of medical wastes has significantly increased in recent years as a result of population growth, an increase in the number of healthcare institutions, hospitals, and medicinal product wastes, especially after the coronavirus (COVID-19) pandemic spread (Arab et al., 2008; Taghipour & Mosaferi, 2009, as cited by Chisholm et al., 2021).

Waste management is an ongoing problem in SIDS due to the continuous increase in waste generation and the lack of effective and sustainable waste management strategies (Mohee et al., 2015). In the international climate change negotiations in 1990, the SIDS emerged as a credible group through the Alliance of Small Island States (AOSIS) (Wong, 2010). Despite not being included in the SIDS list, Aruba is one of the Associate Members of the UN Regional Commissions (Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States, n.d.). Like other SIDS islands, Aruba faces challenges regarding sustainable development because of its small size, geographic location, shortage of raw materials, vulnerability to outside shocks, and substantial reliance on imports of resources and consumer goods (Feenstra & Alofs, 2020).

Relevance and Purpose of Research

Medical waste, commonly referred to as healthcare waste, is one of many various types of waste. The majority of medical waste is generated by everyday activities like hospital administration and the provision of food for staff and patients, but a considerable portion resulting from the provision of medical care is considered dangerous because it could be infectious, contain harmful substances, or result in physical harm (IETC et al., 2021). Moreover, medical waste management is often unsustainable, especially in developing countries. In these countries, medical waste is frequently handled and disposed of with household waste, posing concerns to the environment, the general public, and healthcare personnel. (Ghali et al., 2023).

Waste in Aruba has always been disposed of at landfills. Up until December 2022, Parkietenbos was the only authorized public dump in use on Aruba for the disposal of household and commercial trash. (Workgroup Waste Processing Aruba, 2018). The Department of Public Works (DOW) is operating one incinerator that is used to burn both medical and non-medical waste; but, since the landfill closed, more load was placed on it leading to overload and eventual failure. Numerous media publications have addressed this concern, including a 2023 publication by 24ora highlighting the malfunction of the incinerator. During this period of inactivity, all waste, including medical waste, accumulated, sparking concern as animals began to gravitate toward hazardous materials (24ora, 2023).

Improper medical waste management also infringes on human rights, including the right to a clean environment, the right to safe working conditions, and the right to life and health (Georgescu, 2011, Stringer et al., 2011 as cited by IETC et al., 2021). In addition, inappropriate handling of medical waste goes against the Sustainable Development Goals (SDGs) established by the United Nations in 2015. Specifically, it disregards SDG3, which focuses on ensuring healthy lifestyles and promoting well-being for everyone of all ages, and SDG 12, promoting sustainable patterns of consumption and production.

Consequently, it is essential to look into how medical waste is managed in Aruba and the necessary policy requirements for efficient circular medical waste management. Like other SIDS islands, Aruba faces challenges regarding sustainable development because of its small size, geographic location, shortage of raw materials, vulnerability to outside shocks, and substantial reliance on imports of resources and consumer goods (Feenstra & Alofs, 2020).

According to Feenstra and Alofs (2020), Aruba has four bottlenecks that prevent the development of circular business models in waste management. These concern the island's small waste volumes, the financing restrictions, the antiquated and insufficient legal framework, and the need for more knowledge, awareness, and conscious behavior regarding the circular economy (Feenstra & Alofs, 2020). This study will analyze and evaluate how a circular medical waste management system can be implemented in Aruba, considering the four bottlenecks mentioned above that Aruba faces in the field of circular waste management. The main objective of this research is to determine what policy requirements are needed for an effective medical waste management system. To determine the policy requirements, it is necessary to research the four bottlenecks that impede the development of circular business models and then develop an effective medical waste management system. It's crucial to note that this research is ongoing, and the findings and conclusions presented herein are preliminary.

Research Questions

The main research question of this research is: "How can an effective circular medical waste management system be implemented on Aruba considering scale and waste volumes, financial limitations, outdated legal frameworks, and limited knowledge and awareness on the subject?" To answer the main research question, five sub-questions have been formulated. The sub-questions are:

1. What are the consequences of improper medical waste management, and what techniques can be employed to manage it effectively?
2. What solutions can be considered to manage the scale and volume of medical waste in Aruba?
3. What financial products can be implemented to contribute to an effective medical waste management system?
4. How can legislation and policies be updated to align with the principles of an effective waste management system?
5. What initiatives and awareness campaigns can be implemented to improve awareness of medical waste management?

2. Literature Review

Types of Medical Waste

Approximately 85 percent of the waste produced by healthcare operations is classified as non-hazardous, which refers to waste that does not pose any particular biological, chemical, radioactive, or physical hazard (WHO, 2018). It is estimated that potentially dangerous, toxic, or radioactive compounds make up the remaining 15% (WHO, 2018). According to the World Health Organization (WHO) (2018), this type of waste can be further categorized into seven categories namely; infectious waste, pathological waste, sharps, chemicals, pharmaceuticals, genotoxic waste and radioactive waste.

Consequences of Improper Medical Waste Management

Improper medical waste management carries several potential risks. The Workgroup Waste Processing Aruba (2018) underlines the necessity for an immediate strategy for redirection or treatment at the source since medical waste may include diseases that, if not handled appropriately, might have major public health concerns. Similarly, Babanyara et al. (2013) claim that exposure to medical waste can increase the risk of developing gastrointestinal, respiratory, and skin infections, as well as more serious illnesses, including HIV/AIDS and hepatitis. Medical waste also contains potentially dangerous microorganisms that can infect hospital patients, healthcare professionals, and the general public (Babanyara et al., 2013). Medical waste, if improperly disposed of, not only compromises human health but also pollutes and potentially harms the environment.

Small Scale and Waste Volume

Feenstra and Alofs' research (2020) revealed that Aruba's small size and islandness are among the barriers to sustainable development. Camilleri-Fenech et al. (2018) and Fuldauer et al. (2019) mention the following factors as impacting waste management in small, densely populated, and tourism-dependent island contexts: space availability, scale-related restrictions on recycling and resale opportunities, underdeveloped infrastructure, lack of regulations, and poor enforcement.

Environmental factors play a role in Aruba's lack of local manufacturing and reliance on imports for the majority of its material needs. The island's economies of scale result in small volumes and short value chains (Feenstra & Alofs, 2020). The possibility exists that islands will not generate enough medical waste to support waste processing. Adeoti et al. (October, 2020) researched the role of infrastructure in enabling sustainable, resilient, and inclusive development in small island developing states. According to Adeoti et al. (October, 2020), cooperation among small islands' governments facilitates better access to financial and human resources, which can result in better infrastructure development. Collaborative efforts, like assigning technical specialists to distinct islands, can foster knowledge sharing and creative thinking in infrastructure development. In addition to promoting better export levels and the potential for small islands' developing governments to compete in global markets, inter-island cooperation may provide a list of economic benefits, such as increased economies of scale (Adeoti et al., October, 2020). Moreover, the UN Environment published a report in 2019 called "The SIDS Waste Management Outlook," which provides an overview of the current challenges and opportunities for waste management in SIDS. This report recommended the implementation of a "Hub and Spoke" regional cooperation model in the Pacific to improve the management of hazardous waste.

The model provides for the identification of subregions (e.g. Micronesia) that serve as collection points for an efficient flow of materials from outer islands (e.g. Marshall Islands) to regional centers (e.g. Palau) and then to nearby countries with processing facilities (e.g. Malaysia) by utilizing a reverse logistics approach. This approach exploits the spare capacity of shipping in going from these islands to larger ports. Such an approach would require infrastructure to allow for secure storage of hazardous substances until a viable quantity is built up and ready for transportation (UN Environment, 2019, p.49).

Despite being based in the Pacific, the Hub and Spoke regional cooperation model described in the study may also be applied and modified for the Caribbean. Aruba and other Caribbean islands face similar waste management challenges, particularly concerning medical waste. Feenstra and Alofs' (2020) research underlines the scale-related constraints that small islands such as Aruba confront when it comes to recycling and resale possibilities. This could be an opportunity to work with neighboring islands hoping to find a solution to the problem of small-scale and limited volumes of waste inherent to SIDSs.

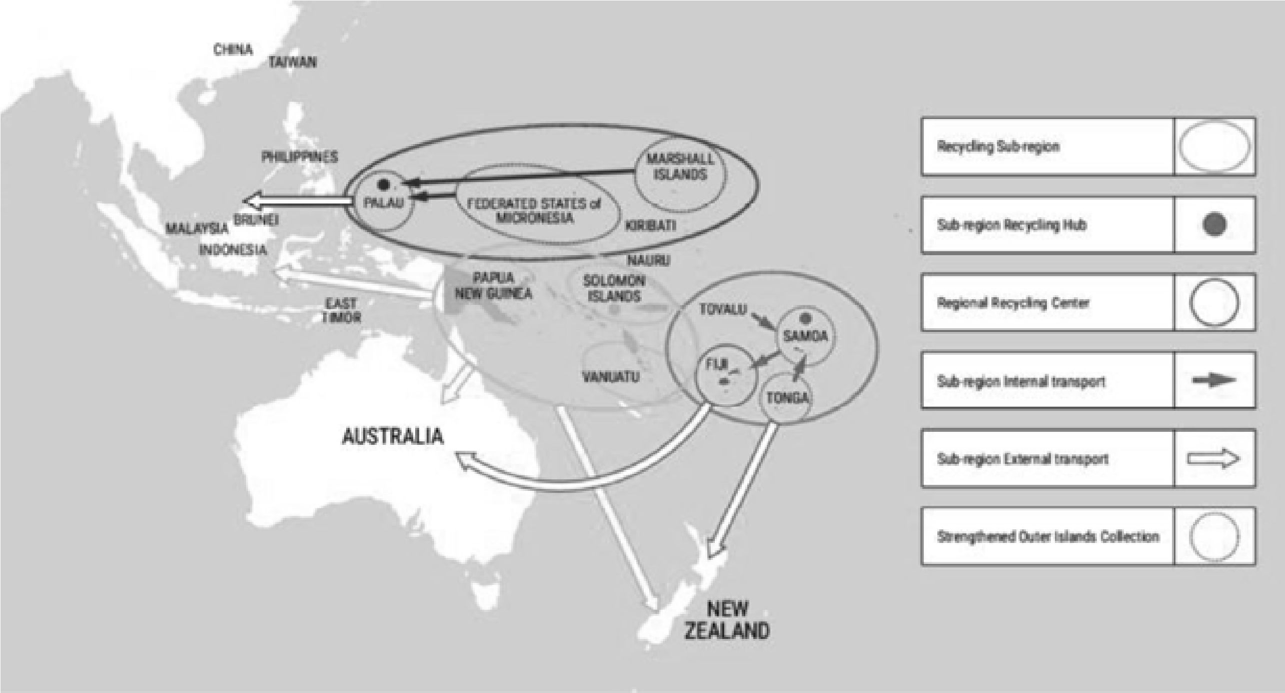

Figure 1: Example of "Hub and Spoke" regional cooperation model for managing hazardous waste

Financial Products

Alongside the government, healthcare professionals, and the general public, financial institutions are also important stakeholders in the push for medical waste circular management. Financial institutions, such as national and international banks, must acknowledge the effects of medical waste and how crucial it is to handle this issue to achieve sustainability. Feenstra and Alofs (2020) examined how the conservatism of local financial institutions causes businesses to frequently face challenges getting financing for their innovative circular businesses or initiatives. According to their research, the companies affected are resolving this issue either through internal finance, seeking international investors, or mergers. An illustration of this is the merging of the former Biofuel company into what is now known as Antilla Energy in 2013, which was made possible by the former company's success in attracting an international group of investors (Feenstra & Alofs, 2020). This was essential since the newly merged local company had a tough time persuading local banks to fund its activities.

Given the conservatism of local financial institutions in the corporate banking sector, it is understandable that businesses are having trouble obtaining financing for their circular company or initiatives (Feenstra & Alofs, 2020). Solutions from various countries have included tax exemptions and lax taxation. Thakur (2021) created a framework for the PESTEL (Political, Economic, Sociological, Technological, Environmental, and Legal) dimensions of sustainable healthcare waste management. One solution proposed in the framework's economic section was to loosen tax laws, which would assist medical waste handlers in establishing new facilities and importing cutting-edge technology to treat infectious wastes with the least amount of carbon footprint (Mkude & Wimmer, 2015; Podein & Hernke 2010, as cited by Thakur 2021). Additionally, it was indicated in the political component of the framework that financial subsidies for medical waste handlers needed to be established. Thakur (2021) mentioned that during the COVID-19 outbreak emergency time, the government could have considered specific financial policies to support the waste-handling sector. Although this is about the COVID-19 epidemic, which has led to an increase in medical waste, it also relates to pre- and post-COVID medical waste.

Legal Frameworks

For a medical waste management system to be effective, proper regulations must be in place and adhered to. Feenstra and Alofs (2020) state that throughout the focus group sessions conducted for their research, stakeholders confirmed the absence of specific legislation aimed at promoting a circular economy and the absence of sanctioning systems. To adopt, modify, and ultimately establish Aruba's legal framework for the management of medical waste, its representatives or lawmakers should study relevant legislation, signed agreements, or treaties that are in use in other countries.

In 1992, the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal entered into force (UNEP, n.d.). This agreement established thirteen general obligations to follow. As per the convention, each party is required to take different actions, such as guaranteeing the availability of sufficient disposal facilities for the environmentally sound management of hazardous wastes and other wastes, which should be located within it whenever possible; making sure that those involved in managing hazardous wastes or other wastes within it take the necessary precautions to prevent pollution from hazardous wastes and other wastes arising from such management and, if pollution does occur, minimizing the consequences thereof for human health and the environment (UNEP, n.d.).

Furthermore, the European Commission developed a Waste Framework Directive. This directive sets the "basic concepts and definitions related to waste management, including definitions of waste, recycling, and recovery" (Waste Framework Directive, n.d.). It also provides "additional labeling, record keeping, monitoring and control obligations from the "cradle to the grave", in other words, from the waste production to the final disposal or recovery" (Waste Framework Directive, n.d.). It also bans the mixing of hazardous waste with other categories of hazardous and non-hazardous waste.

To implement an effective medical waste management system, Aruba can create its national laws by adhering to and incorporating certain elements from international treaties, declarations, and agreements and fitting them into the SIDS context.

Knowledge and Awareness

It is widely acknowledged that developing and successfully implementing sustainable solutions to global issues like resource security and climate change requires a multifaceted strategy involving a variety of actors, including the government, civic society, non-governmental organizations, and the community (Stern, 2006, Marias & de Almeida, 2007, Bodin & Crona, 2009, Weber & Allen, 2010, Phillips et al., 2011, Starkl et al., 2013, Meadows et al., 2014, as cited by Caniato et al., 2015). Stakeholder involvement in waste management can be challenging because each stage of the process, from waste generation to its final disposal, calls for the identification of various stakeholders (Wang et al, 2021). Although Wang et al. (2021) discuss solid waste, this can also apply to medical waste. Thus, for medical waste management to be successful and sustainable, stakeholders' participation, knowledge, and expertise are needed.

Moreover, sustainable management of medical waste also involves governments and political commitment. The willingness and cooperation of governments are essential for maintaining sustainable practices in any industry, particularly when it comes to the treatment of generated byproducts (Thakur & Mangla, 2019; Townend et al., 2009, as cited by Thakur, 2021). Political interventions are necessary to establish and oversee the constitutional framework for managing medical waste through the regulatory body (Song et al., 2017; WHO, 2020 as cited by Thakur, 2021).

Lee & Lee (2022) emphasized two requirements to achieve sustainable medical waste management: raising public awareness of these practices and providing training in them. Clinical staff, according to Lee and Lee (2022), play a crucial role in the sustainability of medical waste management since they sort medical waste at the location of generation. Furthermore, Ozder et al. (2013) did research to determine whether medical waste management training is needed for healthcare professionals. This study has found that training programs on waste management in the healthcare industry significantly increase the knowledge level of the healthcare staff. Lack of proper supervision and training was cited as the most significant issue with waste management (Ozder et al., 2013).

Medical waste management is a topic that must be grasped not just by healthcare professionals, but also by the general public. In his study on managing medical waste sustainably during the COVID-19 outbreak, Thakur (2021) emphasized the importance of raising public awareness of medical waste. The implementation of an effective medical waste management system during a health outbreak, according to Thakur, is also influenced by society's awareness of the infectious medical waste that emerges from virus-infected individuals (2021). A further important obstacle to efficient medical waste management is a lack of public knowledge regarding the treatment of infectious wastes and inadequate education on the adequate handling of contaminated disposable products. Thakur (2021) concentrated on the medical waste associated with the COVID-19 pandemic, but it is also applicable to other viruses and diseases that might spread due to ineffective waste management.

In 2019, Feenstra and Alofs conducted focus groups and interviews as part of their study on circular entrepreneurship in Aruba's waste industry. The focus groups raised the idea of introducing think tanks in Aruba as a means of raising awareness and developing the ability to initiate circular economy projects in business, government, and higher education. A think tank is a research institution dedicated to multidisciplinary study to utilize specialized expertise and network activation to offer recommendations on a wide variety of policy issues and products (Britannica, 2024). To further illustrate, a think tank located on an island similar to Aruba is the Caribbean Policy Research Institute (CAPRI) in Jamaica. It is a non-profit public policy think tank whose mission is to generate and distribute objective, fact-based information to support policy decisions in the areas of economics, governance, sustainability, and social policy in Jamaica and throughout the Caribbean (n.d.). The establishment of think tanks in Aruba could be beneficial for the island's advancement. Waste management, especially medical waste management, is one of the many problems that these research institutions in Aruba might be able to tackle. In addition to researching medical waste, they can provide seminars. These research institutions may also potentially collaborate with other Dutch Caribbean islands, which would benefit not just Aruba but also the other islands.

3. Methodology

Research Design

The research methodology used is the qualitative research approach. Many methods can be used to collect data in qualitative research, such as participant observation, qualitative interviews, and focus groups (Bryman, 2016, p. 377). In this case, qualitative interviewing, specifically semi-structured interviews, was used.

These interviews allow participants to elaborate on their viewpoints and explore issues they believe are significant or pertinent to this research (Bryman, 2016, p. 466). The population sample for the semi-structured interviews comprises a total of 10 participants. The focus of these interviews is on the policy requirements necessary for the effective management of medical waste in Aruba.

Sampling

This study uses purposive sampling. Purposive sampling's underlying principle, according to Bryman (2016, p. 408), is that "the research questions should be an indication of which units needed to be sampled" . During the research, data saturation could happen at some point. Data saturation is "the point in a research process where enough data has been collected to draw necessary conclusions, and any further data collection will not produce value-added insights" (Quantilope, 2023, para. 1). Therefore, three main groups will be interviewed for this research: producers, policy organizations, and waste disposal companies. This will provide a multi-perspective approach to the topic. The participants that will participate in the research include representatives from the hospital, laboratories, and the government of Aruba.

Research Instruments

The research instrument used in this research is semi-structured interviews which consist of open-ended questions aimed at gathering information regarding policy requirements for effective medical waste management in Aruba. Three sets of interview questions have been created, one for each of the three main groups being interviewed. As a result, some interview questions were directed at policy organizations, some toward producers of medical waste and others toward organizations that manage waste. The interview questions are divided into three categories: general questions, core questions, and closing questions. interview cards were created to facilitate the collection of detailed data and assist interviewees in comprehending the questions more thoroughly. These cards contain 11 primary questions, enhanced with follow-up questions and probes aimed at eliciting more in-depth answers.

4. Expected Results

It is expected that conducting semi-structured interviews with stakeholders from different sectors will provide significant and valuable insight into the financial mechanisms, legal framework, and general awareness needed for Aruba's medical waste management to be implemented effectively. Furthermore, it is expected that the analysis of the interview data would highlight reoccurring themes and patterns, offering insightful information for the creation of policies and decision-making. Overall, it is expected that this research will shed light on the medical waste management issues on Aruba, outline potential solutions, and offer recommendations based on the existing literature, perspectives, and experiences of the interviewees.

5. Preliminary Conclusion

In conclusion, it appears that a coordinated and multifaceted approach may be needed to address Aruba's waste management challenges. This results from the wide range of organizations that are involved, including waste producers and disposal firms as well as the regulatory body in charge of the legal framework.The issue of waste management, particularly medical waste, in Aruba presents different challenges that demand urgent attention. Inadequate waste management not only threatens public health but also undermines environmental sustainability, posing significant risks to both present and future generations. Addressing these challenges may require a comprehensive approach that considers the socio-economic and environmental context of Aruba. If Aruba were to consider adopting international best practices, exploring potential financial mechanisms, and possibly enhancing stakeholder awareness, it could potentially develop a more robust waste management system that might safeguard public health and the environment.

However, given the complexity of the issue, it's unclear whether these measures alone would suffice. Collaboration and well-informed decision-making will be crucial in successfully tackling the intricate problems of waste management, but further research and analysis will be required to confirm.

References

- Adeoti, T., Fantini, C., Morgan, G., Thacker, S., Ceppi, P., Bhikhoo, N., Kumar, S., Crosskey, S. y O'Regan, N. (2020, October). *Infraestructura para los pequeños Estados insulares en desarrollo*. Copenhagen (Denmark), UNOPS.
- Babanyara, Y. Y., Ibrahim, D. B., Garba, T., Bogoro, A. G., & Abubakar, M. Y. (2013). Poor Medical Waste Management (MWM) Practices and Its Risks to Human Health and the Environment: A Literature Review. International Journal of Health and Medical Engineering, 7(11), 780–787. https://doi.org/10.5281/zenodo.1089052
- Britannica. (2024, March 8). Think tank | Research, Analysis & Policy Impact. Encyclopedia Britannica. https://www.britannica.com/topic/think-tank/Think-tanks-in-practice
- Bryman, A. (2016). Social Research Methods (5th ed.). London: Oxford University Press.
- Camilleri-Fenech, M., Oliver-Solà, J., Farreny, R., & Gabarrell, X. (2018). Where do islands put their waste? – A material flow and carbon footprint analysis of municipal waste management in the Maltese Islands. Journal of Cleaner Production, 195, 1609–1619. https://doi.org/10.1016/j.jclepro.2017.07.057
- Caniato, M., Tudor, T., & Vaccari, M. (2015). Understanding the perceptions, roles and interactions of stakeholder networks managing health-care waste: A case study of the Gaza Strip. Waste Management, 35, 255–264. https://doi.org/10.1016/j.wasman.2014.09.018
- CAPRI | Caribbean Policy Research Institute (CAPRI). (n.d.). https://www.capricaribbean.org/about/overview
- Chisholm, J. M., Zamani, R. R., Negm, A. M., Said, N., Daiem, M. M. A., Dibaj, M., & Akrami, M. A. (2021). Sustainable waste management of medical waste in African developing countries: A narrative review. Waste Management & Research, 39(9), 1149–1163. https://doi.org/10.1177/0734242x211029175
- Feenstra, B., & Alofs, L. (2020). Circular business strategies and supply chain finance in the Aruba waste sector: A case study of a small island jurisdiction. *Small States & Territories*, 3 (1), 209-228.
- Fuldauer, L. I., Ives, M. C., Adshead, D., Thacker, S., & Hall, J. W. (2019). Participatory planning of the future of waste management in small island developing states to deliver on the Sustainable Development Goals. Journal of Cleaner Production, 223, 147–162. https://doi.org/10.1016/j.jclepro.2019.02.269
- Ghali, H., Cheikh, A. B., Bhiri, S., Bouzgarrou, L., Rejeb, M. B., Gargouri, I., & Latiri, H. S. (2023). Health and Environmental Impact of Hospital Wastes: Systematic review. Dubai Medical Journal (Online), 6(2), 67–80. https://doi.org/10.1159/000529432
- IETC, IGES, CCET, & HCWH. (2021, November). HEALTH CARE WASTE MANAGEMENT TOWARDS THE CIRCULAR ECONOMY A CASE STUDY AT TRIBHUVAN UNIVERSITY TEACHING HOSPITAL IN NEPAL. https://www.ccet.jp/. https://www.ccet.jp/sites/default/files/2022-03/Napal%20case%20study_web.pdf
- Lee, S. M., & Lee, D. (2022). Effective Medical Waste Management for Sustainable Green Healthcare. International Journal of Environmental Research and Public Health, 19(22), 14820. https://doi.org/10.3390/ijerph192214820
- Medical Waste. (2022, May 14). US EPA. https://www.epa.gov/rcra/medical-waste
- Mohee, R., Mauthoor, S., Bundhoo, Z. M., Somaroo, G. D., Soobhany, N., & Gunasee, S. (2015). Current status of solid waste management in small island developing states: A review. Waste Management, 43, 539–549. https://doi.org/10.1016/j.wasman.2015.06.012
- Ozder, A., Teker, B., Eker, H. H., Altındis, S., Kocaakman, M., & Karabay, O. (2013). Medical waste management training for healthcare managers - a

necessity? Journal of Environmental Health Science and Engineering, 11(1). https://doi.org/10.1186/2052-336x-11-2

- Thakur, V. (2021). Framework for PESTEL dimensions of sustainable healthcare waste management: Learnings from COVID-19 outbreak. Journal of Cleaner Production, 287, 125562. https://doi.org/10.1016/j.jclepro.2020.125562
- UNEP: Basel Convention on the Control of Transboundary Movements of Hazardous Wastes
- and Their Disposal. (n.d.). https://wedocs.unep.org/bitstream/handle/20.500.11822/8385/-Basel%20Convention%20on%20the%20Control%20of%20Transboundary%20Movements%20of%20Hazardous%20Wastes%20-20113644.pdf?sequence=2&amp%3BisAllowed=
- UN Environment (2019). SIDS Waste Management Outlook.
- Wang, K. C. M., Lee, K. E., & Mokhtar, M. (2021). Solid Waste Management in Small Tourism Islands: An Evolutionary Governance Approach. Sustainability, 13(11), 5896. https://doi.org/10.3390/su13115896
- Waste Framework Directive. (n.d.). Environment. https://environment.ec.europa.eu/topics/waste-and-recycling/waste-framework-directive_en
- World Health Organization: WHO. (2018). Health-care waste. www.who.int.
- Workgroup Waste Processing Aruba. (2018). Final Report Integrated Solid Waste Management Aruba.
- Quantilope. (2023, April 12). Data Saturation in Qualitative Research. MRX Glossary. https://www.quantilope.com/resources/glossary-data-saturation-in-qualitative-research

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My time in Aruba has been a whirlwind of wonder.

During my stay in Aruba, I feel as if I have gone through many changes. I've come to realize what a privilege it is to be great friends with your neighbors, and to be able to meet up regularly outside of class. I am not limiting this to planned outings, as day to day interactions and small chit chat have been a blessing. My social experiences as a whole, with my fellow exchange students, and the Aruban students, have been nothing but extremely fulfilling. Academically I have also learned a lot. Firstly, not properly scheduling things is an awful mess. Secondly, reaching out to those who are willing to help is key. I used to avoid asking for help as I felt like what I was asking for would make me look foolish, and that I would be wasting others' time. Yet, I was completely open to helping others with nearly anything. This double standard that I applied to myself was a little ludicrous. I am so thankful to be surrounded by many kind and helpful people, who have enabled me to come so far. Thirdly, do not wait passively if you require information or assistance from someone. If they are not showing signs of availability, search for alternatives. And better yet, focus on the things you still can do while waiting. I experienced several mental blocks, feeling like I could do nothing, when I clearly could have. I do not intend to let this happen again, and even if it does, I will mitigate it further. The last point I have, because it is so dear to me, is cultural, including culinary experience. Learning about the culture of the island, including the Papiamento language was great. Trying new foods, and even attempting to cook them, experimenting, is very fun and enriching. Just recently, I made fried banana and naranjilla mixed together with cinnamon and panela to form a delectable spread. I had not been exposed too very much, if at all to naranjilla, plantain, tamarillo and other fruits, and I must say it would be a missed opportunity to not experiment with them. Going to local markets like STR agriculture farm has also been very informative, as I discovered local products such different hot sauces, and the

“Ponchi Crema”. Additionally, learning about the natural environment of Aruba has been a pleasure. Researching on my own, but also listening to people who know and are more than willing to talk about the place is great. In conclusion, I recommend to those seeking an enriching cultural, personal and academic experience to join the UAUCU program.

Effects of Invasive Species: Impacts of *Cryptostegia grandiflora* on soil pH

Martin Soubelet

Invasive species are a problematic group of species in many parts of the world, especially small islands (Tye, 2018). Their impacts are wide ranging, affecting economies and societies as well as ecosystems and their processes. One such invasive species is *Cryptostegia Grandiflora*, invasive in many arid and semi-arid parts of the world, and often introduced for the purpose of rubber production. This paper will propose a research plan for the effects of this plant on soil, primarily concerning the island of Aruba, but may also be applied elsewhere. We will first focus on the process leading to the creation of invasive species and their impacts. Then, we will discuss the specifics of how invasive species may impact soil. After this, we will present characteristics of *C. grandiflora* and its specific impacts. Finally, we will discuss the proposed research method to study its effects on soil pH.

We begin with detailing definitions and how invasive species come to be. The current ecological model for the realization of an invasive species involves a multistep process from which a species native to an area is brought somewhere new, where it may establish and propagate. Firstly, the cycle begins with a native species, one that is within its natural range. This range can shift without the involvement of humans (IPBES, 2023). This native species may also be brought outside of its natural range, past the ecological barriers which define it, as a consequence of human activities. It is then classified as an alien or exotic species in this new area. Ornamental and agricultural plants are common examples of such species. Of these alien species, a few may establish themselves, producing a self-sustaining population, which may begin to spread later on. There are then two paths for these species after establishment. On the one hand, they may find their own place in their new environment, without entirely replacing the indigenous species. On the other hand, they may begin to spread out of control and negatively impact native biodiversity and ecosystems. They would then be considered an invasive species, and it is believed that 1 in 1000 established species become invasive (Burg et al., 2012 ; IPBES, 2023).

We will now further detail what impacts invasive species have on the native ecosystems that they disturb. As mentioned previously, the consequences reach far and wide, and have been vastly documented in literature across a multitude of studies. We will focus on summing up a few of the most notable direct and indirect effects from the “Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services” (IPBES) report on “Invasive alien species and their control” (IPBES, 2023). Firstly, invasive species drive out native species or other alien species and can even lead them to go extinct and can drastically change biodiversity. These species also have negative impacts for industries heavily dependent on plants and livestock, such as agriculture, thereby impacting food security. This could be from the introduction of non-native pests, or even the diseases invasive species carry with them, which also pose a threat to human and animal health (Chinchio et al., 2020). Additionally, many invasive species, being well adapted to quickly extracting resources such as water and resources, also increase water scarcity. These effects ultimately have a negative impact on human health. Secondly, invasive species can also increase the marginalization of certain activities or communities. As mentioned, activities dependent on nature are the most affected, meaning that those dependent on it the most are also the most impacted. Many groups, including migrants, indigenous peoples, poor rural communities are disproportionately affected not only by the invasive species themselves, but also by the diseases they may carry. Overall, invasive species are extremely problematic and require adequate action (IPBES, 2023). Unfortunately, current management practices have proved insufficient, and further action is needed. It is very difficult to deal with invasive species, as they generally spread quickly, a characteristic responsible for their status. Now that we have detailed the overall impacts of invasive species, we will move on to that of a specific species as a case study.

Now that we have made a general overview of invasive species, we will cover the topic of invasive plants. Given the large differences in biology between animals and plants, there are many specificities to the establishment and propagation of the latter. This next section will cover how invasive plants alter abiotic properties of the soil to benefit their own establishment. Plants are known for having an inextricable link to the soil, from which they extract the necessary water and nutrients to produce their organic matter, using their vast network of roots. The acidity, soil infiltration, water content, K, N and P levels directly affect the growth of plants. However, plants can also modify these parameters to their advantage, facilitating their own establishment. This also naturally applies to invasive plant species. A positive change in the surrounding soil caused by a plant is known as the "island of fertility" hypothesis. This process describes multiple phenomena. Firstly, the plant produces organic matter. The leaves, fruits, and other parts may fall off and decompose, producing litter, increasing soil organic matter (SOM). This may also decrease the soil's pH. The plant can also release protons and organic acids through their roots into the rhizosphere, directly reducing the pH. The rhizosphere is the term that describes the nearby soil whose properties may be affected by the plant. Furthermore, the plants increase fertility by depositing carbon and nitrogen rich compounds, which in turn increases the quality of the litter. Coupled together, these mechanisms improve the surrounding soil, facilitating establishment and growth of the invasive species (Souza et al., 2023). There is clear evidence that *C. madagascariensis* fulfills this hypothesis. It has been shown to have decreased pH, and increased contents of phosphorus and nitrogen in invaded environments (SOuza et al., 2015, Souza et al., 2023). In Brazil where Souza et al. carried out their studies, they have shown that the native litter was in fact less fertile than that of *C. madagascariensis* (Souza et al., 2023). It is therefore worth investigating if *C. cryptostegia* does the same.

This paper focuses on one invasive species in particular, *Cryptostegia grandiflora. C. grandiflora* is a species of what is commonly called "rubber vine". It is also known as Cordon di San Fransisco in Papiamento. It is a woody perennial vine native to Madagascar and parts of tropical Africa (Burg et al. 2012; Tomley, 1995). As previously mentioned, the genus also has another species, *Cryptostegia madagascariensis,* native to Madagascar as well (Tomley, 1995). It has elliptic leaves that are glossy green and its flowers are pale pink and white, seen in figure 1 below (Cordon di San Fransisco ; Tomley, 1995).

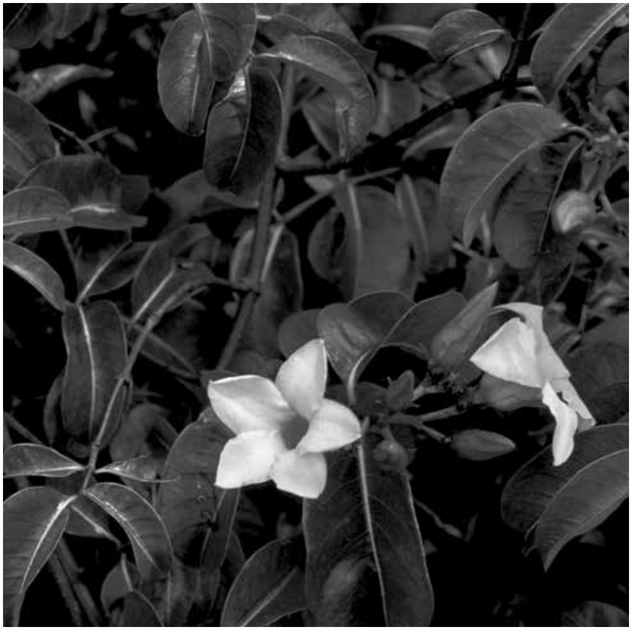

Fig 1. Photograph of *C. grandiflora* By Forest & Kim Starr (CC-BY)

Its many stems intertwine with each other, or with a host plant allowing it to climb high and form large thickets. This plant is also able to spread rapidly, growing up to 5 meters a month in the rainy season, and release a great amount of seeds at once (Burg et al., 2012 ; Cordon di San Fransisco). It is quite hardy and stress tolerant, able to grow in a very wide range of soil conditions. *C. grandiflora* is invasive in many semi arid to arid parts of the world, including but not limited to Australia, Ethiopia, Mexico, the United States and the Caribbean (Burg et al., 2012, Luizza et al., 2016 ; Rodríguez-Estrella, 2010). It is quite problematic in all of these areas. It is known for forming large thickets covering all vegetation, reducing accessible sunlight (Luizza et al., 2016). *C. grandifora* can also quickly outcompete natives and form monospecific stands especially in riparian areas, as it has been observed in Baja California, Mexico (Rodríguez-Estrella et al., 2010). It has also had negative consequences on domestic livestock production, as the animals depend on these riparian areas for food (Kriticos et al., 2003). In Australia, it has also been shown to have severely changed fire regimes, "promoting frequent crown-fires" (Luizza et al., 2016, Radford et al., 2008). Further, because it is so competitive in arid environments, it extracts what little water is present there, leaving native species under more stress. Overall, it has been shown to reduce native biodiversity and species richness (Luizza et al., 2016). These impacts are also predicted to become widespread, as the distribution of *C. grandiflora* may increase with climate change (Kriticos et al., 2003). As for the lesser Antilles, especially Aruba, research on its impacts has been sorely lacking. Indeed, the only research paper associated with this plant and Aruba is a report from the University of Wageningen, Burg et al. 2012. Neither is there any data present in Aruba's own national archives (Coleccion Aruba), or the public archives of the Directorate of Nature and Environment. Descriptive information can be found in "Arnoldo's Zakflora. Wat in het wild groeit en bloeit op Aruba, Bonaire en Curaçao." by Ketner P., which is a book detailing the flora of the ABC islands, as well as in the Aruba National Park Foundation Fact sheet on the plant (Cordon di San Francisco).

Now, we will detail a research proposal with a relatively simple protocol to study the impact of rubber vine on soil pH. Preliminary observations, as well as discussions with the National Aruba Park Foundation indicate that *C. cryptostegia* is primarily found in disturbed areas, along roads and water runoff passages. It is also found around "cactus fences". One can often find parallel rows constructing a path in the middle. According to a member of the Department of Agriculture, Livestock and Fishery of Aruba, these fences were grown for the purpose of creating safe paths for traveling, as well as fencing of private property. By driving through Aruba looking for rubber vine, 28 sites were established. The site coordinates where the rubber vine was found were recorded and input into google maps.

They are displayed in the map below:

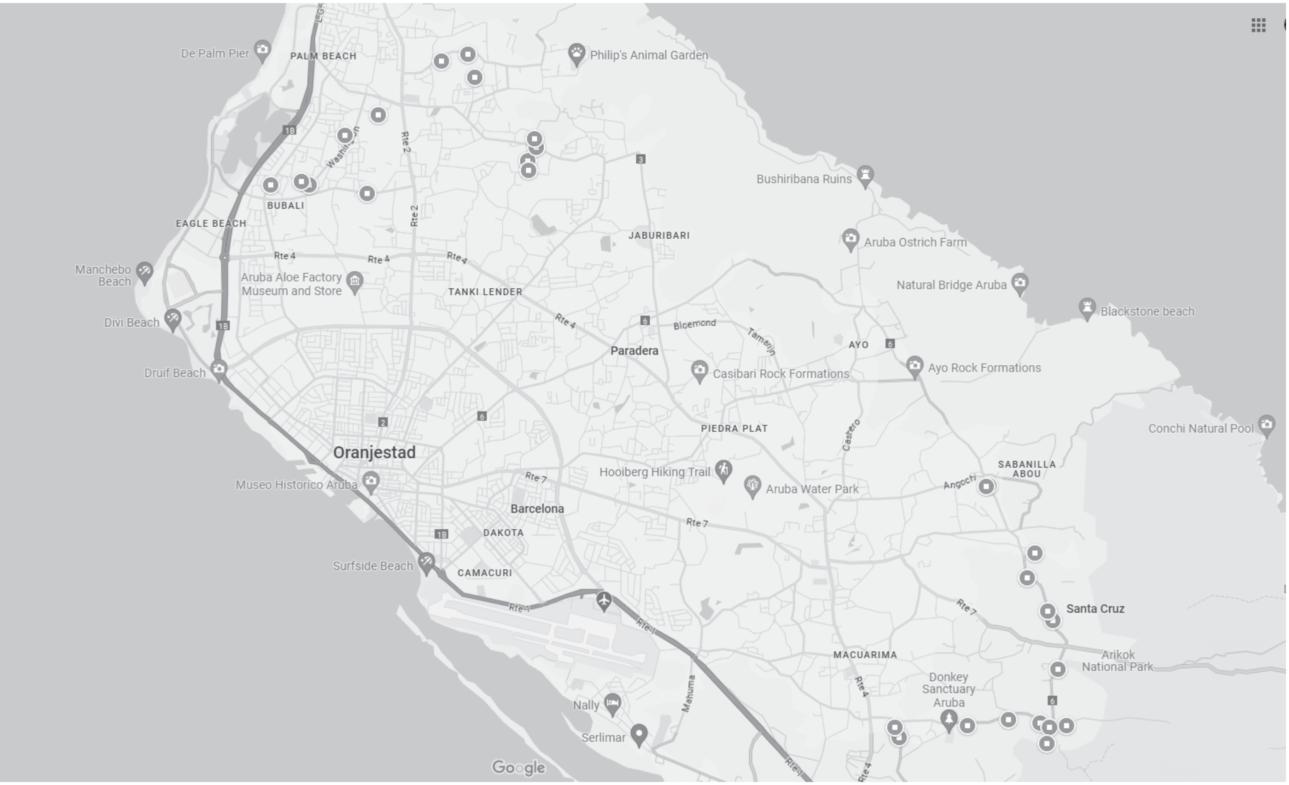

Fig2. Map of *C. grandiflora* locations in Aruba. A marker symbol consisting of a circle with a square in its center indicates the presence of *C. grandiflora*.

After identifying locations of rubber vine, plots must be defined. This research is structured around paired plot design. That is, for each plot that is invaded by rubber vine, another plot was drawn nearby with similar conditions without rubber vine. This enables a comparison to be made allowing to determine whether rubber vine has effects on the soil. It is important that other conditions such as soil type and the type of environment (e.g. dry shrubland, forest, proximity to roadside etc.) be considered to reduce confounding factors. The main factors controlled were soil type, litter quantity, ground and tree cover (species and approximate density). Due to time limitations, these controls were done through visual observation only. Species were not all identified, but parity of species between plots was ensured. Proper cover measurements as well as soil texture tests are recommended. Each plot may be 2x2 m, and the ones containing invasive species should be centered around a rooting stem. This size is chosen as the thickets range greatly in size, and may be extremely small, as well as some sites being near cactus fences, which present a physical boundary. In each plot, a trowel was used to take 3 random samples, from 0 to 10 cm depth. A trowel was used as the soil was much too dry to use a soil core borer. Indeed, the soil would simply fall back into the hole that was bored. Place the samples in a plastic bag. Each plot must have the texture of the soil tested to ensure proper parity. One possible method is the bolus and ribbon test. Soil is moistened and kneaded into a ball. The soil to water ratio is then adjusted until the soil just "fails to stick to the fingers". This soil ball, or bolus, is then pressed into a ribbon. The length and width of the ribbon can then be evaluated to determine the soil type, following a flow chart (Commonwealth Scientific and Industrial Research Organisation, 1997). As mentioned previously, this test was not able to be put into practice. Soil type parity was assessed by comparing samples visually and through touch. After collection of the soil, bags were left open to dry for a minimum of 24 hours, to ensure that the samples were dry. Were this research to be carried out during the wet season, higher drying times may have been required. So far, 8 samples were taken at 4 sites. 10 sites and 20 samples is the current objective. This concludes the research carried out. The next paragraph describes the following steps for this research.

After collecting the soil samples, pH will be tested. 10 grams of soil will be mixed with 25 ml of distilled water in a beaker. The contents will be stirred for 10 minutes using a magnetic stirrer. Then, leave the contents to settle for another hour. This will allow the separation of a liquid and solid phase. Some of the liquid will be transferred into another beaker using a pipette. Finally, a calibrated pH meter will be used to finally measure the pH of the liquid phase. This protocol is based on the international standard, ISO 10390-2021. For statistical methods, paired design tests will be used. There are of course limitations to this field method. Seasonal variations, as well as local varying disturbances may affect the properties of the soil. The results will provide further insight on what effects *C. grandiflora* may have on the soil. Additionally, because of the lack of robust measurements of plant cover and soil type, parity between sites may also be affected to some degree. Further research should be carried out to also look at the organic properties of soil, such as the microbiome, which is still not fully understood.

In conclusion, invasive plant species are a worldwide problem with far reaching negative impacts. They directly affect native biodiversity, and all those who depend on it, including various animals, and of course, humans. Invasive plants can increase the fertility of the surrounding soil around them to their own benefit. It is then proposed to investigate if a species of rubber vine, *Cryptostegia grandfilora*, can affect the soil abiotic properties, notably pH.

References

- Chinchio, E., Crotta, M., Romeo, C., Drewe, J. A., Guitian, J., & Ferrari, N. (2020). Invasive alien species and disease risk: An open challenge in public and animal health. *PLoS pathogens, 16*(10), e1008922. https://doi.org/10.1371/journal.ppat.1008922
- *Coleccion Aruba*. (n.d.). https://coleccion.aw/pages/pa/home/
- *Cordon di San Francisco*. (n.d.). Aruba National Park Foundation. Retrieved April 15, 2024, from https://www.arubanationalpark.org/main/wp-content/files/pdf/flora/cordondisanfrancisco.pdf
- Forest & Kim Starr, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=6174693
- *Search*. (n.d.). Directorate of Nature & Environment | Directie Natuur & Milieu - Aruba. Retrieved April 15, 2024, from https://dnmaruba.org/en/search/
- Kriticos, D. J., Sutherst, R. W., Brown, J. R., Adkins, S. W., & Maywald, G. F. (n.d.). *Climate change and biotic invasions: A case history of a tropical woody vine.*
- Ketner, P. (2001). *Arnoldo's Zakflora. Wat in het wild groeit en bloeit op Aruba, Bonaire en Curaçao*. Walburg Pers.
- Luizza, M. W., Wakie, T., Evangelista, P. H., & Jarnevich, C. S. (2016). Integrating local pastoral knowledge, participatory mapping, and species distribution modeling for risk assessment of invasive rubber vine (Cryptostegia grandiflora) in Ethiopia's Afar region. *Ecology and Society*, 21(1), art22. https://doi.org/10.5751/ES-07988-210122
- Radford, I. J., Grice, A. C., Abbott, B. N., Nicholas, D. M., & Whiteman, L. (2008). Impacts of changed fire regimes on tropical riparian vegetation invaded by an exotic vine. *Austral Ecology, 33*(2), 151–167. https://doi.org/10.1111/j.1442-9993.2007.01803.x
- Rodríguez-Estrella, R., Navarro, J. J. P., Granados, B., & Rivera, L. (2010). The distribution of an invasive plant in a fragile ecosystem: The rubber vine (Cryptostegia grandiflora) in oases of the Baja California peninsula. *Biological Invasions, 12*(10), 3389–3393. https://doi.org/10.1007/s10530-010-9758-z
- Roy, H. E., Pauchard, A., Stoett, P., & Renard Truong, T. (2024). *IPBES Invasive Alien Species Assessment: Full report* (Version 4). [object Object]. https://doi.org/10.5281/ZENODO.7430682
- Souza, T. A. F. D., Rodriguez-Echeverría, S., Andrade, L. A. D., & Freitas, H. (2016). Could biological invasion by Cryptostegia madagascariensis alter the composition of the arbuscular mycorrhizal fungal community in semi-arid Brazil? *Acta Botanica Brasilica, 30*(1), 93–101. https://doi.org/10.1590/0102-33062015abb0190
- Souza, T., Lucena, E. O. D., De Andrade, L. A., Da Silva, L. J. R., Nascimento, G. D. S., & Freitas, H. (2023). Litter Deposition and Nutrient Cycling of Invaded Environments by Cryptostegia madagascariensis at Tropical Cambisols from Northeastern Brazil. *International Journal of Plant Biology, 14*(1), 254–265. https://doi.org/10.3390/ijpb14010021
- The Commonwealth Scientific and Industrial Research Organisation. (1997). *Current Biology*, 7(3), R126. https://doi.org/10.1016/S0960-9822(97)70976-X
- Tomley, A. J. (n.d.). *The Biology of Australian Weeds 26. Cryptostegia grandiflora R. Br.*

Alexandra Falcon, University of Aruba

When the academic year came to an end I decided to join the SISSTEM program.

In 2019 I was a student in the academic foundation year here at the University of Aruba trying to find out what I wanted to do next in my academic journey, since I was little I thought that when I grew up I would become a doctor and help heal people but I started doubting myself, and if that was what I wanted to do for real, during my first year at the university I got to learn many new things including more in-depth information about sustainability. When the academic year came to an end I decided to join the SISSTEM program. I found a new goal, help find solutions to challenges that our environment was facing, and help heal our planet little by little.

This year as a SISSTEM student I got to join this class and talk about the sustainability challenges that the world faces today with other students. As a SISSTEM student sometimes my perspective is very technical when it comes to sustainability but during this class, I was able to see the different challenges that small islands like Aruba face from the perspective of my peers who have different backgrounds when compared to mine. This class made me question the meaning of different things that I have not given so much thought about before, one of the things that one of my peers pointed out and that got stuck in my mind was the meaning of development and how it means continuous change but for sustainable development when is the development enough or is the change that is needed to reach total sustainability unreachable?

Even though talking about sustainability problems, solutions and the actions that need to be taken to reach sustainability can be depressing sometimes this class made me realize that more people care about these challenges and that collaboration between different disciplines is the key to finding solutions that take into account not only the environment but also the people living in it and that there is beauty in this all, we don't always have to focus on the negative side of something.

As small as my contribution can be I hope that through my research I can help heal the environment a little.

Unveiling Hotspots in Hydroponic Lettuce Production

Alexandra Falcon

Introduction

Small island developing states (SIDS) are a unique group of countries that face unique social, economic, and environmental challenges and vulnerabilities. (UN, n.d) Aruba as a SIDS in the Caribbean is not immune to these challenges. The island faces challenges such as the dependency on food imports, scarcity of good quality topsoil, scarcity of freshwater, and dependency on fossil fuels. During the pandemic, Aruba's vulnerability and the necessity to create resilience against external shocks, especially when it comes to food security, became more evident than ever. That led to the creation of a strategy to strengthen food security by expanding the national agricultural sector. (Boyer et al, 2020) In addition, the government of Aruba (GoA) recently established a fund, AGRIFUND, to stimulate the growth of the agricultural sector innovatively and sustainably. (GoA, 2024). Other initiatives to expand the agricultural sector include the creation of syntropic gardens in multiple elementary schools around the island.

Currently, the agricultural sector of Aruba is relatively small compared to other existing sectors such as the tourism sector. But in the last years, there has been a growth in local farmers. Even though the characteristics of Aruba's soil and climate make it difficult to grow vegetables and fruits using traditional approaches, people have found non-traditional innovative ways to grow vegetables and fruits, such as cucumber, strawberries, lettuce, and other leafy greens. One method used nowadays is hydroponics. Hydroponics is used in different configurations to grow fruits and vegetables such as cucumber, leafy greens, and lettuce. This paper aims to give an insight into what significant sustainability challenges, also known as hotspots, can be found in hydroponics lettuce production using the life cycle assessment.

Context

Aruba is a small island state located in the Caribbean with an area of about 193 km2 with approximately 107566 inhabitants (CBS, 2023), and a fluctuating tourist population. In January of 2024, Aruba had a total arrival of 117,172 tourists (ATA, 2024). The climate of Aruba is mostly dry with a rainy season from October to December. Aruba's climate is semi-arid to arid with an average temperature of 28.1 C. Aruba soils are characterized as being poor in nutrients. (CIMH & WMO, 2018)

Fresh water is not naturally available on the island, the water consumed in Aruba is produced by WEB, using seawater reverse osmosis (SWRO) desalination process. (WEB, n.d.) Aruba's electricity system consists mostly of a production of

110 MW, with a mix of different sources. 18.1% of energy is produced with wind, 0.8% with solar, and 81.1% is produced using heavy fuel oils (HFO) (WEB, n.d).

Literature review

This literature review aims to explore and analyze information about LCA, hydroponics, and existing research on LCAs of lettuce production in other countries and identify hotspots that can also be present in the Aruban context.

Life cycle assessment (LCA) is a known methodology used to evaluate the environmental impact of products and their production process. LCA consists of four phases, 1. Goal and scope and definition, 2. Life cycle inventory analysis (LCI), 3. Life cycle impact assessment (LCIA) and 4. Life cycle interpretation. (ISO,14044:2006) Phase 1 consists of defining the goal and scope involves choices that play a big role when in later phases of the LCA. This phase includes defining the main question that needs to be answered and defining the functional unit or quantitative description of the product, function, or service that is being assessed. Defining the system boundaries includes deciding which activities and processes are part of the product's life cycle, and which parameters, and geographical and temporal boundaries are relevant in the product life cycle. (Hauschild, 2018) Phase 2 is a life cycle inventory analysis. In this phase information about the inputs and outputs of the processes that belong in the system boundaries, is collected and analyzed to create the life cycle inventory. (Hauschild, 2018) Phase 3 is a life cycle impact assessment, in this phase the data collected in the life cycle inventory is translated into the impacts on the environment that the product has. (Hauschild, 2018) Finally phase 4 focuses on interpretation, in this phase the environmental impacts are interpreted and used to answer the main question defined in Phase 1. (Hauschild, 2018). Impact categories explored when performing an LCA include global warming, acidification, freshwater eutrophication, marine eutrophication, resource depletion, land occupation, and water usage.

Hydroponics is a method of planting in which unlike in traditional farming soil is not used and is replaced by a solution containing nutrient minerals. The use of hydroponics systems has multiple advantages it results in a higher yield, requires less land, less water, and less fertilizer, and is very versatile and supports continuous production during the year (Barbosa et al, 2015); Bascombe, 2016). When using this technique the plants grow using a substrate that supports the stem of the plant, the substrate can be natural or man-made. There exist multiple configurations of hydroponics, which one should be used for the cultivation of a plant depending on the local climate, and the necessities of the specific plant, among other factors. The most common components of a hydroponic setup include a storage tank to store the nutrient solution and an aerator.(Velazquez-Gozales, 2022). Leafy vegetables such as lettuce have proven to grow better using the nutrient film technique (NFT) (Tognoni, 2014) The NFT system consists of gullies or channels in which the plants grow, the roots of the plant are continuously kept moist by a thin layer of nutrient-rich water that is pumped through the gullies. (Sheikh, 2006) In Aruba farms like Cunucu Fresh use the NFT hydroponics method to grow lettuce. (Jacobs, 2023)

LCA has shown to be an important assessing tool and is widely used in agricultural production in many countries to understand the environmental impacts associated with a product or process, LCA helps identify hotspots that can be improved to be more sustainable. In a study by Casey et al (2022), the environmental efficiency of the production, packaging, and transport of lettuce for hydroponics and conventional field production was researched using the LCA methodology, during the study 10 different scenarios were compared. These scenarios consisted of six controlled agricultural environments that used hydroponics and four open-field environments. these scenarios were powered using different energy sources like wind, solar (off the grid), wind (on and off the grid), and the grid with a mix of different energy sources such as natural gas, renewable, nuclear, coal, and hydropower. The scenarios were located in various climate zones, which included Spain, Great Britain, the coast and desert of the USA, Norway, and South Africa. The scenarios also had different transport configurations. This study showed that hydroponics systems are highly efficient in terms of water and land use. Still, they are also highly susceptible to the source of energy used to power the system due to the high consumption of electricity for lighting, cooling ventilation, and pumping, the approximation of electricity used per kg of lettuce is 15 kWh. Compared to continental and international supply chains, hydroponics systems can produce lettuce with comparatively small environmental footprints when electricity is sourced from a clean grid (e.g. Norwegian grid) or using a dedicated renewable energy generation such as a medium-scale wind power generation.

In a different study by Martin et al (2023), the environmental impact of the production of packaged lettuce in a large-scale vertical farm (VF) in Sweden was analyzed and compared to imported and conventional lettuce supplies. Four different scenarios were compared to test the sensitivity of lettuce production to the energy source used during production. The baseline scenario, VF-lettuce was modeled using the average Swedish electricity mix which consists of 39% hydropower, 41% nuclear power, 10% wind power, 9% heat and power, and less than 1% solar power, the second scenario VF-lettuce wind was power with a 100% wind power, the third scenario, VF-lettuce wind/hydro was powered 50% wind and hydropower, the fourth scenario was modeled using the Nordic electricity mix. When comparing the different scenarios it was found that electricity sourcing has a high impact on the environmental impact of the different scenarios. When comparing it was shown that the scenarios that used wind and wind/hydropower as the source of energy have lower GHG emissions. The baseline scenario has a carbon footprint of 0.98 kg CO2-eq/kg edible lettuce and the scenario with the Nordic energy mix has a footprint of 1.08 kg CO2-eq/kg edible lettuce the scenarios using renewable energy have a footprint of 0.77 kg CO2-eq/kg edible lettuce (wind) and 0.75 kg CO2-eq/kg edible lettuce for the wind-hydropower mix. Other findings were that the scenarios using renewable energy use less land and fossil resources. Moreover, the scenarios using renewable energy have a larger use of mineral and metal resources. When it comes to water use the scenario with the Nordic energy mix and the scenario with a mix of wind and hydropower have the highest use of water. In this study, the impact of VF was also compared with the imported lettuce supply and the local conventional supply of lettuce. When comparing VF with imported lettuce it was shown that VF has a lower GHG emission. The study showed that when comparing vertical farming and the production of lettuce in local greenhouses, vertical farming has a slightly lower emission of GHG. When comparing the production of lettuce in open fields (OP), hydroponics, and polytunnels (PT) with VF; OP, and PT may have lower GHG emissions due to the low energy consumption of the production, hydroponics is also likely to have lower emission of GHG when compared to VF. When it comes to the potential ecotoxicity of freshwater imported lettuce and OP lettuce have a lower impact than VF lettuce and GH lettuce due to the high consumption of electricity in the production of lettuce on VF and GH.

Results & discussion

From the literature previously mentioned some hotspots in lettuce production using hydroponics can be identified, the main hotspot is the high emission of GHG due to the high consumption of energy for ventilation, lighting, and pumping of water. A second hotspot is the sensitivity of the hydroponic system to the source of energy use, renewable or nonrenewable, the source has a big impact on the GHG emissions of the system.

There are differences between the hydroponic systems mentioned above and the systems in Aruba one example is the need for lighting. In Aruba, the existing farms have an infrastructure that lets natural lighting pass through it which means there is no need for artificial lighting. Another difference is that Aruba's freshwater source is desalinated water that uses fossil fuels to produce the water. Aruba's electricity grid is mostly power-using HFO, meaning that the electricity used to power the hydroponics systems is likely to be the highest contributor to the GHG emissions of said system.

Conclusion

This paper provided an introduction to topics like life cycle assessment and hydroponics. With the existing research that was mentioned in this paper, it was possible to identify possible hotspots in the hydroponic systems in Aruba such as sensitivity to the energy source and the impact of energy use in the GHG emissions. To further investigate the environmental impact of lettuce production and the hotspots of using hydroponic systems in Aruba there is a need to perform an LCA for a more in-depth analysis using data collected from an existing lettuce farm. In the future, I will dive deeper into the carbon footprint of lettuce production in Aruba by performing an LCA.

References

- *ATA statistics.* (2024). https://www.airportaruba.com/tourism-statistics
- Barbosa, G. L., Almeida Gadelha, F. D., Kublik, N., Proctor, A., Reichelm, L., Weissinger, E., Wohlleb, G. M., & Halden, R. U. (2015). Comparison of Land, Water, and Energy Requirements of Lettuce Grown Using Hydroponic vs. Conventional Agricultural Methods. *International Journal of Environmental Research and Public Health, 12*(6), 6879-6891. https://doi.org/10.3390/ijerph120606879
- Bascombe, K. (2016). HYDROPONICS: An eco-friendly approach to water management. *Spore, 181*, 28–29. http://www.jstor.org/stable/43831884
- Boyer Mary, Horton John, Millán María Florencia, Grosjean Christophe Frederic Robert, Arias Ramón Ernesto, Lopez Elena Mora, Wrede Peter, de Kort Rendell Ernest, Justiniano Ivelisse and Chapman Regis. 2020. 'Building Resilience in Aruba's Food Security During the COVID-19 Pandemic and Beyond.' World Bank: Washington D.C
- Casey, L. M., Freeman, B., Francis, K., Brychkova, G., McKeown, P. C., Spillane, C., Bezrukov, A. A., Zaworotko, M. J., & Styles, D. (2022). Comparative environmental footprints of lettuce supplied by hydroponic controlled-environment agriculture and field-based supply chains. *Journal of Cleaner Production, 369*, 133214. https://doi.org/10.1016/j.jclepro.2022.133214
- CBS Aruba (2022, November 24). *The development of the population of Aruba.* https://cbs.aw/wp/index.php/2022/11/24/test-births/
- CIMH & WMO. (2018, June 18). *Country profile – Aruba.* Caribbean Regional Climate Centre. https://rcc.cimh.edu.bb/country-profile-aruba/
- Government of Aruba. (2024, April 11). First step taken to finance the agricultural industry (Agrifund). *Government of Aruba.* https://www.gobierno.aw/en/

first-step-taken-to-finance-the-agricultural-industry-agrifund

- Hauschild, M. Z. (2017). Introduction to LCA methodology. *In Springer eBooks* (pp. 59–66). https://doi.org/10.1007/978-3-319-56475-3_6
- ISO 14040:2006, Environmental management — Life cycle assessment — Principles and framework
- Jacobs, M (2023, June 30). *Aruba: "We've built a new greenhouse every year since 2020."* https://www.verticalfarmdaily.com/article/9541701/aruba-we-ve-built-a-new-greenhouse-every-year-since-2020/
- Martin, M., Elnour, M., & Siñol, A. C. (2023). Environmental life cycle assessment of a large-scale commercial vertical farm. *Sustainable Production and Consumption, 40*, 182–193. https://doi.org/10.1016/j.spc.2023.06.020
- Sheikh, B.. (2006). Hydroponics: Key to sustain agriculture in water stressed and urban environment. Pak. J. Agric., Agric. Eng. Vet. Sci.. 22.
- Tognoni, F. (2014). *Methyl Bromide Alternatives for North African and Southern European countries: Chapter 15. Soil-less Culture for Greenhouse Crops in the Mediterranean Countries*.
- UN (n.d.). *About small island developing states | Office of the High Representative for the least developed Countries, landlocked Developing Countries and small island developing states.* https://www.un.org/ohrlls/content/about-small-island-developing-states
- Velazquez-Gonzalez, R.S.; Garcia-Garcia, A.L.; Ventura-Zapata, E.; Barceinas-Sanchez, J.D.O.; Sosa-Savedra, J.C. A Review on Hydroponics and the Technologies Associated for Medium- and Small-Scale Operations. Agriculture 2022, 12, 646. https://doi.org/10. 3390/agriculture12050646
- *WEB Aruba N.V. | Water- en Energiebedrijf Aruba N.V.* (n.d.). https://webaruba.com/energy/power-production-figures
- *WEB Aruba N.V. | Water- en Energiebedrijf Aruba N.V.* (n.d.). https://webaruba.com/water-production

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Little did I know the real impact that my time in Aruba would have on me.

The opportunity to do research in Aruba for my bachelor's thesis is both a privilege and an opportunity that I will forever be grateful for. Being an anthropologist I have had the pleasure of reading multiple ethnographic accounts and have had ample discussions on the intricacies of fieldwork. However, I often felt that I would not be able to do much anthropological fieldwork within my bachelor's, as these serve more as foundational years. However, the opportunity to come to Aruba presented itself, and soon after the first meeting with Eric, I already had a group to do research with; the volunteers from Turning the Tide. Little did I know the real impact that my time in Aruba would have on me. I had been so focused on the preparation of the research before coming, that I had barely had the opportunity to realize that I was going to be living in a country completely foreign to my own for the next two months and a half.

As an international student, I am aware of how moving countries can have a profound effect on individuals. However, I was not ready for the hospitality and kindness with which we were received, by students, teachers, locals, and everyone we encountered. The warmth of the people, and that of the environment is a memory that I will forever cherish. I will never forget all the adventures that we went on to the north coast or the Parke Arikok. These were the experiences that I wasn't anticipating but made my time on the island so much more valuable to my personal growth.

Furthermore, I could not have anticipated the way that the experiences with my research had a profound impact on the way I viewed the environment. Working in coral out-planting through a volunteer-based project here on the island, I was SCUBA diving every weekend. With underwater life being a passion of mine already, volunteering for Turning the Tide represented a glimpse of the life that I want to live in the future – not as a researcher but as being

actively engaged in environmental efforts. I will be forever grateful to Tobia who helped me join in the volunteer efforts; to Sietske who would organize and coordinate the dives; to Dana, Jef, and Marc, new and unexpected friends who taught me so much about ocean life here and abroad; to all the UA students who were open to talking with me and sharing their experiences with me; and to everyone else who made the experience unforgettable and created such a welcoming atmosphere.

Actions Speak Louder Than Word: The Importance of First Hand Experience in Nature Conservation

Uxue Gantxegi

Introduction

The network of issues of climate change stem from an energy system that is rooted in the exploitation of natural resources, one which necessitates collective action to enact any meaningful change (Wuebbles, 2001; Höök & Tang, 2013; Schenck, 2008). The heavy use of fossil fuels as our main source of energy has had detrimental issues on the planet's ecology which have created a *positive feedback loop* leading to the world's 6th mass extinction that we are currently living in (Ceballos et al., 2015). This is a narrative that I, and many other young adults in the so called global north have grown up with. Starting early in my life, there were discussions of recycling and ways of energy saving, for example, my parents would have a shared laundry machine so that we would use less water. I have often been involved in discussions, in school and social circles, about the need for collective action in order to mitigate the repercussions of climate change. My childhood, spent in a little village in the north of Euskadi (northern Spain), surrounded by lush forests and ample space for us to play in, resulted in a deep care for the environment which has only flourished throughout my life. My father would often organize little hikes for us to go in, and my grandfather had a vegetable garden near our house that he would tend to, and teach us about. These embodied contacts that I had with nature during my childhood heavily shaped my passion for nature conservation and my need to be out in nature, where my environmental subjectivity, as described by Agrawal (2005) started to be formed. It was in my adolescent years that I first started scuba diving and learning about the way that climate change was affecting ocean ecosystems and biodiversity through experiencing coral bleaching in the Philippines. Having the privilege to dive in places like the Philippines and Indonesia, where there are ample reefs of all colors imaginable, my care for the environment is focused on ocean and reef conservation. My own personal history with environmental activity - as active full-bodied experience with the natural world is what I find to be the catalyst to my environmental subjectivity. Thus this research focuses on how this environmental activity might shape the subjectivities of agents to become more environmentally inclined.

In response to the pressing need for coastal ecosystem restoration within the island of Aruba, collaborative efforts have been undertaken through the Turning the Tide project. This initiative, funded by RESEMBID, is a collaborative project between Wageningen Research University, the University of Aruba (UA), Scubble Bubbles Foundation, and Fundation Parke Nacional Aruba (Aruba National Parks Foundation). It aims to kick-start the restoration of the interlinked mangrove and coral reef ecosytems. The project, which I have had the honor to be part of, also focuses on involving the community in the conservation efforts through providing them with scuba diving and Global Coral Reef Monitoring Network (GCRMN) training and involving them in the monitoring of the coral reefs and the outplanting of corals. The involvement of these volunteers and how this work has shaped their subjectivity is of central interest for this paper. By examining the varied experiences of volunteers, this study seeks to elucidate how active involvement in conservation efforts influences individual subjectivities and underscores the potential transformative power of such initiatives.

Theoretical Framework

At the center of this research is the transformation of individual subjectivities into what Agarwal refers to as environmental subjectivity; people for whom *"the environment is a conceptual category that organizes some of their thinking and a domain in conscious relation to which they perform some of their actions."* (2005, p162). Agarwal's exploration of "Environmentality" delves into the intricate process through which individuals develop a concern for the environment, elucidating the interplay between governmental, individual, and communal dynamics. He adopts the Foucauldian concept of governmentality to analyze the way in which subjectivities come to be intertwined with political institutions when nature comes to be a space that requires protection and regulation. This way, environmentality becomes a means through which environmental subjectivities arise through the interaction of beliefs, perceptions and actions to shape the individual subjectivities (Agrawal, 2005). meaning that environmental subjects reflect upon how their actions influence the environment, and will consider it in their everyday decision making. Central to subject formation is the interaction between personal and collective beliefs, as individuals navigate between the private and public realms. However, Agarwal contends that it is the active engagement in nature conservation practices that fundamentally shapes environmental subjectivities (Agarwal, 2005). This involvement underscores the active nature of environmental subject formation as being constituted through practices, as an embodied and enacted process of active engagement with the environment.

The concept of subjectivity as grounded in practice bears resemblance to Bourdieu's notion of habitus, often criticized for its deterministic outlook and neglect of individual reflexivity (Sayer, 2010). However, as suggested by Nicos Mouzelis (2008), rather than discarding the concept entirely, there is merit in its modification (Sayer, 2005). By understanding habitus as a *"kind of osmosis or unconscious adaptation through to a more conscious process of learning how to do things so that we can do them without thinking"* the understanding of subjectivity as an embodied process enhances the traditional view of subjective formation (Sayer, 2010, p.88).This more holistic understanding of embodied subjectivity, further expands the understanding of how our everyday activities - whether environmentally driven or not, shape subjectivities. This theory aims to go beyond the cartesian division of body and mind, and in turn engage the ways in which mind and body are in a dialogical relationship and thus intrinsically linked (Cromby, 2005). This perspective underscores the interplay between conscious learning processes and embodied experiences, informing individuals' values and beliefs. Such an approach encapsulates the reflexivity inherent in subject formation, as observed by Agrawal in his analysis of environmentality.

This phenomenological approach to subject formation recognizes the transformative potential of everyday conservation experiences, particularly for individuals engaged in repeated environmental practices, such as the volunteers of the Turning the Tide project. It emphasizes the reciprocal relationship between individual consciousness and embodied experiences, wherein environmental challenges become focal points for the reflexive construction of habitus. Thus, the intimate nexus between individuals and their environment, facilitated by conscientious practice and awareness, fosters the emergence of environmental subjectivities. This conceptual framework will guide the analysis of volunteer experiences within the Turning the Tide project, elucidating the intricate interplay between individual agency and environmental engagement.

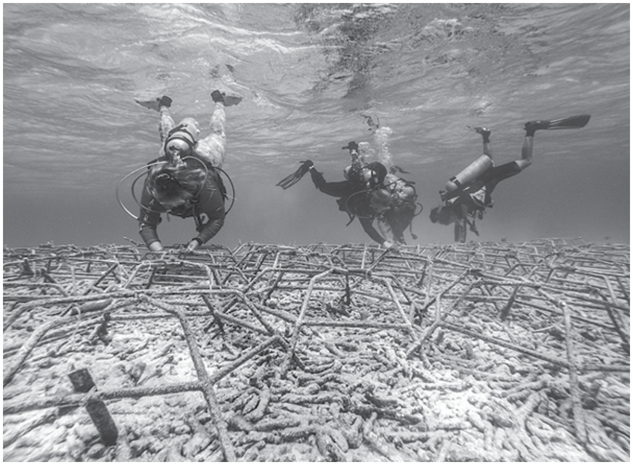
Methodology

To comprehensively unravel the intricate processes involved in the development of environmental subjectivities, this study employs a multifaceted methodology encompassing participatory action research (PAR) and semi-structured interviews conducted with various volunteers affiliated with the Turning the Tide initiative. PAR involves the active participation of an ethnographic researcher within the field they are studying (Ortner, 1984). In this case, my volunteering within the Turning the Tide project allowed me to delve deeper into the nuances of subject formation by undergoing the same experiences as the volunteers who will be interviewed. Consequently, this methodology not only facilitates an understanding of the volunteers' perspectives but also engenders a transformative effect on my own subjectivity. This deeply engaged approach to research underscores the ethical imperative of reciprocity and respect, particularly given the researcher's privileged position as an investigator granted access to the lives of others. It is because of this that I have decided to conduct the interviews at the end of the out-planting phase of the project, to allow for more reflexive conversations and to be engaged in volunteering wholeheartedly, further embracing my personal subjective transformation through this process. Furthermore, I put myself in the position of both the researcher and the participant to avoid hierarchical relations within the research.

Following the completion of the coral planting phase, I sat down with the volunteers to discuss how and if the volunteer work had affected them. This phase of the research involved seven participants; Four of them were UA students who were part of the program in a volunteer capacity; Two marine biology master students from Wageningen University who were volunteering and also gathering data for their thesis; and one 22 year old local participant who heard about the project through Scubble Bubbles. These participants were a select group of people from the project, and so they only represent a portion of how this project has affected various other volunteers.

Preliminary Findings

During my paticipation in the project, I have witnessed the creation of a small yet diverse community, drawing in numerous volunteers to build the artificial reef structures, out-planting the corals, and now monitoring their growth. The diverse nature of these tasks has led to differing levels of engagement among volunteers, reflecting varying degrees of involvement in the project, and with it, varying levels of subjective transformation. First off, UA students and staff had to become certified in diving, and for some this required them getting the license to begin with. After making sure that all the volunteers were certified, both students and staff members had to take a two-part Global Coral Reef Monitoring (GCRM) course. They first had to learn the theory and then do a series of practice runs. The course was in preparation for the prolonged involvement in the monitoring of the coral reefs throughout Aruba, as well as monitoring the reefs that were out-planted throughout the project. During this time, a larger group of local volunteers were involved in the construction phase of the Mars Assisted Reef Restoration System (MARRS),



You can see the maars reef system that is composed by sets of umbrella star structures to which the coral get attached to.

These structures were then placed at various coastal areas of Aruba in preparation for the coral out-planting, constituting the phase I actively participated in. This is followed by the monitoring of how these reefs are progressing, which the trained staff and students could participate in.

The out-planting phase entailed four consecutive weekends of volunteer engagement, primarily focusing on artificial reef cleaning and coral fragments out-planting. On Saturdays, around five to twelve divers, depending on the number of reef systems that we would have to tackle, would gather for the cleaning of the MARRS reefs. Equipped with metal bristle brushes and gloves, volunteers meticulously removed algae and debris from the reefs, a task often described as meditative. Divers were divided into groups, where each group was assigned a specific MARRS structure to clean, and would work alongside two 'finishers' - often the organizers of the project - who would go around loosely attaching tie wraps for subsequent attachment of the corals on the following Sunday. The volunteering on Saturdays involved mostly one single dive, where each volunteer worked individually on their cleaning task.

In contrast, Sundays consisted of lengthier volunteering sessions, commencing with boat departures between 8:00 and 8:30 AM and concluding between 1:00 and 4:30 PM, depending on the number of planting sites that needed to be attended to. Sundays required a collaborative effort between diverse volunteer groups, each with different roles assigned for the out-planting. Most volunteers operated in traditional diving buddy pairs, with one individual responsible for carrying baskets containing coral fragments, divided by genotypes, while the other affixed these fragments to the reef using pre-positioned zip ties. Consequently, specific genotypes were strategically placed within designated areas of the reef, requiring vigilant coordination between diving pairs. Similar to Saturdays, Sunday's volunteering also maintained a pair of finishers, whose duties entailed securing coral fragments with additional zip ties and trimming excess plastic. Often, when volunteers with other roles had finished their tasks, they would join in cutting off the excess plastic of the zip ties to get the work done more efficiently, highlighting the extent of collaborative effort on the Sunday dives.

You can see in the background buddy pair, one holding the basket, while the other is attaching the coral to the system.

All of this work was done by divers with diverse levels of experience, who had arrived at the project at different times in various ways, yet each individual contributed with equal dedication, enthusiasm, and commitment toward the shared goal of coral reef restoration. Since the coral planting phase represented a highly anticipated culmination of the project, the organizers put together a post-final-dive celebratory gathering wherein I was able to observe the gradual cohesion among participants into a community of environmentally driven subjects. Remarkably, in a short amount of time, we were able to plant over 1,400 coral fragments and even build an awareness of the reef health of the island (as pointed out by Jef, one of the master students during his interview). Interestingly, the enthusiasm for the work that we were doing did not decrease over time and every weekend I was met with the same excitement and passion for the volunteering efforts as the first. The enduring enthusiasm underscores the collective commitment to the project's objectives, with volunteers consistently demonstrating eagerness to immerse themselves in underwater activities, irrespective of the duration spent on the boat.

Having spent time with them as a volunteer myself, I have been able to witness the ways in which people with very different backgrounds have come to be deeply impacted through this work. Some of the volunteers have a history of environmentally conscious action. while others are experiencing that through the Turning the Tide project. Throughout the volunteer engagement, several prominent themes emerged, illuminating the participants' deep-seated awareness of the interconnectedness between their actions and broader environmental consequences. The first thing that stood out to me was how the participants saw the work that they were putting in was entangled and intertwined into environmental consequences. There would often be conversations of returning to the island once the reefs had grown and how great it would be for future generations, demonstrating a conscious process of grasping environmental challenges and the impact of your actions. These deliberations underscored varying degrees of environmental consciousness among participants. Moreover, these discussions transcended the immediate tasks at hand, reflecting a broader awareness of environmental challenges and a commitment to mitigating them through everyday actions. Suggestions, such as utilizing metal zip ties proposed by one volunteer during post-activity interviews, underscored a collective ethos of combating plastic pollution and striving for environmental integrity. This illustrates how participants had a regard for the effect of their activities on the environment. Notably, these dialogues not only nurtured individual environmental subjectivities but also fostered an environmentally conscious community of volunteers similar to Agarwal's findings (2005). Additionally, the inclusion of diverse perspectives and histories, stemming from both local participants and foreign volunteers, enriched the community's environmental awareness through environmentally oriented knowledge transfer, fostering a sense of unity and cohesion within the community as an environmental collective.

The autoethnography revealed that this experience had a profound transformative impact on me, not only in fostering a heightened environmental consciousness permeating my daily activities but also in instilling a sense of optimism for the future. While this is not something that I anticipated in preparation for my research, I found that my pessimistic view of the future of the planet slowly altered through witnessing the tangible efforts dedicated to environmental betterment instilled in me a newfound belief in the efficacy of collective action. This, I believe, is pivotal in my transformation into a more environmental subject, as it has motivated me to continue to work on similar projects in the future. This optimism was not limited to myself, and I often observed it among other volunteers on the boat. The minimal apprehension regarding the possibility of failure of the project was prominent, particularly in the project's early stages. Furthermore, updates shared via a group chat on coral monitoring post-planting reflected encouraging results, reinforcing this positive mindset. This optimism, further expanded my environmental subjectivity, as it gives me hope that the work we are doing will have a positive impact on the overall environment.

Interviews

The interviews revealed that the transformation into environmental subjects took time and experience, thus the experience from Turning the Tide had a varying impact based on the personal histories of the volunteers. These conversations revealed the true range of experience that the different volunteers had with environmental action, encompassing both theoretical knowledge of environmental issues and active participation in climate mitigation endeavors such as beach clean-ups, coral planting, and reforestation efforts, correlated with their environmental subjectivities.

Notably, the two master's students from Wageningen University demonstrated their environmental subjectivity in how they related to the environment. Dana, one of the students, shared her deep connection with nature, emphasizing humanity's intrinsic dependence on the natural world:

"I think you are part of nature. I think it's crazy that people think that we are above nature because that's not true, you need nature, and we need nature, we are nature so…"

Her perspective stemmed from a lifelong engagement with environmental issues, including formal education on climate change and early involvement in environmental activities such as becoming a SCUBA instructor at a young age. As she mentioned herself *"I think [environmental action is] kind of a positive feedback loop, because it enhances, it strengthens 'ok you are actually doing something that makes you feel satisfied'* you want to do more of it" highlighting the continuous becoming of an environmental subject. Dana's narrative highlighted the transformative nature of environmental action through time. This position was shared by Jef, the second master's student. His upbringing was characterized by exposure to environmentally conscious practices instigated by his parents, through travel and participation in environmentally focused camps. For Jef, these early experiences laid the foundation for his environmental subjectivity, shaping his beliefs and actions toward nature conservation. Overall, Dana and Jef's narratives exemplify the profound impact of early exposure to environmental issues and consistent engagement in environmental action on the development of environmental subjectivity (Wells & Lekies,2006).

In contrast to the experiences of the master students, some UA students volunteering for the project had shorter histories of environmental actions especially underwater action influencing the transformational effect of Turning the Tide project. For instance, one of the volunteers had to learn to swim to participate in the program. During our interview, Stephen revealed that his journey toward developing environmental subjectivity began during his academic foundation year at the University of Aruba, approximately a year before his involvement in the volunteering project. It was during this period that he first became aware of environmental issues and developed a burgeoning passion for environmental protection. This newfound awareness prompted him to engage in various environmental activities through internships, which further nurtured his growing commitment to environmental conservation. This is a very different history to that of the master students, yet, as Dana articulated, Stephen's journey demonstrates how participation in environmental protection activities can initiate a positive feedback loop, fostering a deepening passion and commitment to environmental stewardship.

An intriguing theme that emerged from these discussions was the pivotal role of SCUBA diving within the Turning the Tide project. Notably, some volunteers cited diving as their primary motivation for joining the initiative. For those requiring certification, diving offered a novel opportunity to explore underwater environments in ways previously inaccessible to them. As one volunteer described, diving enabled them to immerse themselves in what felt like a "secret" world beneath the waves. Moreover, for seasoned divers, participation in the project provided an avenue to participate in a beloved activity at no cost, with the added benefit of contributing positively to environmental conservation efforts. This observation stood out to me given the inherently immersive nature of diving, which highlights embodied action due to limited communication and the unique sensory experience of underwater exploration. Therefore, SCUBA diving within this project becomes a very transformative experience in itself, and by adding environmental action, this embodied experience further enhances the environmental subjectification through the immersive experience of it. While the impact of the Turning the Tide project may not have significantly altered the environmental subjectivity of highly experienced divers, it held profound implications for novices venturing into environmental engagement for the first time. Indeed, for these individuals, the project catalyzed future environmental endeavors, igniting a desire to continue supporting similar initiatives and actively participate in climate mitigation efforts communicated in the interviews. Furthermore, many volunteers of the University of Aruba expressed a commitment to maintaining their environmental engagement beyond the project's scope, indicating a sustained dedication to environmental stewardship. It is noteworthy that even volunteers less affected by the project had extensive backgrounds in environmental activism, suggesting that their participation reflects a continuation of pre-existing environmental subjectivities rather than a transformative moment.

Preliminary conclusion

In conclusion, this essay delves into the multifaceted journey of environmental subject formation through active engagement in conservation efforts, with a particular focus on the Turning the Tide project in Aruba. At its core, the research investigates the transformation of individual subjectivities into environmentally conscious agents, as articulated by Agarwal's concept of environmental subjectivity (2005). By analyzing the diverse experiences of volunteers involved in the project, this study illuminates the intricate interplay between personal histories, collective actions, and embodied experiences in shaping environmental subjectivities. The research underscores the transformative potential of everyday conservation practices in fostering environmental consciousness, as individuals navigate between personal beliefs and collective environmental endeavors. Drawing on Agarwal's notion of environmentality (2005) and a reflexive understanding of Bourdieu's concept of habitus, the study highlights the reciprocal relationship between individual agency and environmental engagement (Sayer, 2010). Through a phenomenological lens, it explores how immersive experiences such as SCUBA diving intersect with environmental action to deepen individuals' environmental subjectivities. The findings reveal a spectrum of experiences among volunteers, reflecting diverse pathways to environmental subject formation. From seasoned environmental advocates to newcomers, each volunteer's journey is shaped by unique personal histories and levels of engagement with environmental issues. Nonetheless, the shared commitment to conservation efforts fosters a sense of community and collective awareness, transcending individual subjectivities to form an environmentally conscious collective.

Ultimately, this research contributes to our understanding of the nuanced processes involved in environmental subject formation, emphasizing the role of active engagement and collective action in shaping individual and collective environmental consciousness. By shedding light on the transformative power of everyday environmental practices, the study underscores the importance of fostering environmentally conscious communities for collective action toward mitigating climate change and safeguarding our planet's future.

Sources:

- Agrawal, A. (2005). *Environmentality: Technologies of government and the making of and history, 26*(1), 126-166.
- Ceballos, G., Ehrlich, P. R., Barnosky, A. D., García, A., Pringle, R. M., & Palmer, T. M. (2015). Accelerated modern human–induced species losses: Entering the sixth mass extinction. Science advances, 1(5), e1400253.
- Cromby, J. (2005). Theorizing embodied subjectivity. *International Journal of Critical legacy* (pp. 99-113). Routledge.
- Höök, M., & Tang, X. (2013). Depletion of fossil fuels and anthropogenic climate change—A review. Energy policy, 52, 797-809.
- Mouzelis, N. (2008) *Modern and Postmodern Social Theorizing*, Cambridge: Cambridge University Press.
- Ortner, S. B. (1984). Theory in Anthropology since the Sixties. *Comparative studies in society Psychology, 15*, 133-150.
- Sayer, A. (2005) *The Moral Significance of Class*, Cambridge: Cambridge University Press.
- Sayer, A. (2010). Bourdieu, ethics and practice. In *Cultural analysis and Bourdieu's subjects.* Oxford University Press.
- Schenck, L. (2008). Climate change crisis-struggling for worldwide collective action. Colo. J. Int'l Envtl. L. & Pol'y, 19, 319.
- Wuebbles, D. J., & Jain, A. K. (2001). Concerns about climate change and the role of fossil fuel use. Fuel processing technology, 71(1-3), 99-119.
- Wells, N. M., & Lekies, K. S. (2006). Nature and the life course: Pathways from childhood nature experiences to adult environmentalism. Children, youth and environments, 16(1), 1-24.

Pictures:

Credit to Tobia De Scisciolo for the images taken on the last day of coral planting; .

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Giving Something Back.

For those reading this, some people don't know me. What am I suggesting with this phrase? Well, what I mean is that some people don't know who I am, what I do, or what I speak. I will state that I don't speak that much Papiamento. For the majority of my life, I only spoke English and Dutch. Even though I was born and raised in Aruba. I did not begin speaking Papiamento until I started MAVO. Where it became a requirement to speak, write, read, and understand the language. This fact may lead some to believe that I'm an outsider, that I didn't fit in the community. However, this is far from the truth. I've got to meet and befriend many Arubans. Some did find it strange that I didn't speak that much Papiamento. That didn't stop us from communicating. When I needed assistance with speaking Papiamento, they didn't hesitate to help. The same applied to when they needed help with Dutch or English. This is something I will always appreciate. When you meet a stranger, there will always be a chance to befriend them or if anything get help from them. When I eventually started speaking Papiamento more. I was able to connect with my people better. I was able to understand the conversations between locals. I felt as if I was able to relate with my people more.

It felt as if I was being accepted. This does not mean I did not feel accepted before however, just understanding the language better really helps me understand the local community more. This all does culminate in the purpose of my research. I know that Papiamento is not the most popular language in the world. Probably because it is only known to the residents or descendants of Aruba, Bonaire, and Curacao. Nonetheless, Papiamento is a beautiful language and should be appreciated for its existence. Furthermore, one way of preserving a language is having it be incorporated into technology.

When I read the list of topics for a thesis, I knew that this one may be challenging. Luckily, I do like a challenge. Moreover, I feel that this would be my way of giving thanks to the island I can call home. To the people, I can call my friends. Even though I may not know everyone.

In a sense, this is what I want to consider, giving something back.

Speech-to-text model for keyword spotting applications in the Papiamento language

Joel Riven Rajnherc

Papiamento, with an estimated 200,000 speakers worldwide, is the language spoken by the local population on the former leeward Netherlands Antilles, Curacao, Bonaire, and Aruba and by emigrants from these islands in the Netherlands and elsewhere (Arends et al., 1995). Papiamento is a well-established Creole language. Papiamento is recognized as an official language. The language has its own literary tradition, plays a role in the educational system, and is used in newspapers in Aruba, Curacao, and Bonaire.

However, there is limited speech technology for the Papiamento language, specifically in the involvement of voice assistant devices and smart speakers.

Summa Linguae (2022) discusses voice assistants such as Amazon Alexa, Google Assistant, and Apple's Siri, speech technology applications widely used by consumers. Each of these voice assistant applications supports several international languages such as English, French, German, Hindi, Italian, Japanese, Portuguese (Brazilian), and Spanish. As of April 2021, Amazon Alexa supports eight languages and various dialects, with plans for future expansion; Apple's Siri supports 21 languages, with live translation capabilities, and Google Assistant leads with over 40 languages supported, focusing on conversational AI development. (Summa LinguaeTechnologies, 2022). Papiamento, however, is not among the languages supported by any of these systems. Even more specialized language technology is found in 'smart speakers', described by Sunshine (2021b) "as systems comprising speakers, microphone arrays, embedded computers, and machine learning-based intelligent assistants, capable of continuous monitoring of the home environment. Furthermore, smart speakers interact with users through conversation, passively identify medically relevant diagnostic sounds, and actively sense physiologic parameters using internal hardware like sonar, radar, or computer vision". These technologies are likewise unavailable for the Papiamento language because teaching voice assistants new languages is challenging due to the need for extensive speech data collection, natural language understanding, and localization. Expanding language support for Papiamento requires demographic research, data collection, and testing.

The ambitious purpose of this research is to attempt a Papiamento speech-to-text keyword system for voice commands within a hospital environment. This would reduce the gap of the limited application of the Papiamento language in artificial intelligence (AI) technology. Furthermore, this research will help keep Papiamento alive for future generations.

To create voice assistants, machine learning is used. Machine learning (ML) is a branch of artificial intelligence (AI) and computer science that focuses on using data and algorithms to enable AI to imitate the way that humans learn. (IBM, n.d.). One of the methods used being investigated is speech-to-text (STT) also known as automatic speech recognition (ASR). STT applications utilize machine learning techniques to accurately understand and transcribe spoken language. STT has applications across various domains such as virtual assistant, dictation software, voice search, transcription services, and accessibility tools for individuals with disabilities. Speech-to-text is a possible starting point for implementing Papiamento in more complex technology. Keyword spotting is another technique used in STT. According to Mary and Deekshitha (2018), "Keyword spotting (KWS) refers to the spotting and retrieval of predefined keywords from audio database". For the proposed research, an audio database will be made of recordings by Aruban Hospital staff. The use of the healthcare environment optimizes the possibilities for this research as a pilot project.

A review of the literature on the Papiamento language, ML techniques on Creole Languages, AI of Keyword spotting, and smart speakers used in healthcare environments is essential in designing and executing this pilot project.

Research Question:

In the following section the proposed research question are presented, they are to be considered as placeholders. These questions won't be answered in this paper but they provide a sense of direction and focus for the research.

The main research question is: What is necessary to develop a Papiamento speech-to-text keyword model for a local hospital environment?

To achieve this the following sub-research questions will have to be addressed:

- Which use cases are applicable in a hospital environment?
- Which Papiamento keywords are applicable within the identified use cases?
- Which neural network architecture(s) apply to the identified use cases?
- What is according to the future users of the solution, an acceptable accuracy?
- Which SDGs are applicable?

However these answers do not fall within the scope of this review of the literature.

Methodology:

The method of this manuscript is limited to a review of the available literature. The information in the previous section is simply a general introduction to the main topic of this research. However, the literature review will delve further into the main subject by dividing this into four sub-topics. The first section discusses the Papiamento language. The second section contains a review of existing models for language similar to Papiamento. The third section discusses the AI mechanics of keyword spotting. The last section relates to the use of smart speakers in healthcare environments.

Literature review:

Papiamento:

Arends et al. (1995) discuss the origins of Papiamento, concluding that it emerged in the 17th century and is primarily based on Portuguese and Spanish. Papiamento is also influenced by African and Amerindian vocabulary and some words from Dutch, and English languages due to historical contact. Furthermore, they extensive describe the Orthography and Phonology of this language. Their research proves that the language's syntax shows that basic word order is similar to other creole languages, with subjects preceding verbs. Researching other available creole STT systems can be used a strong basis for the creation of a system for Papiamento. In short, Arends et al. (1995) highlighted various linguistic features and socio-historical influences that shaped the Papiamento language. Implementing these aspects will ensure that the creation of the STT system will be as optimal as possible.

Another article by Kester and Buijink (2023) discussed the language dynamics, attitudes, and identity in Aruba. They also focused on the status of Aruba's language, Papiamento. Even though the Dutch language has historically dominated, it doesn't change the fact that Papiamento is deeply intertwined with Aruba's identity. Increased English and Spanish influence, raise concerns about the future of Papiamento. Carroll did find a positive attitude towards Papiamento but had concerns about the language's vitality. Implementing Papiamento in technology will support its vitality. Kester and Buijink's (2023) findings indicate that Papiamento remains widely used, especially among younger generations and those with migrant backgrounds. This suggests that Papiamento should be included in technological advancements. Younger generations will have to deal with more technology in their future. Implementing these tools in Papiamento will facilitate the learning process. Despite being a multilingual society, Papiamento still resonates with the local population's sense of heritage. Increased involvement of Papiamento in technology, will contribute to the preservation of this language for future generations and could possibly promote the usage of this language to communities outside of the former leeward Netherlands Antilles islands.

ML techniques on Creole Languages

Schieferstein (2018) researched the challenges that neural language models face when processing low-resource languages. Neural language models, try to predict the most appropriate word to fill in a blank space in a sentence. Neural language models process high-resource languages better than low-resource languages, due to them having more linguistic data, written text and audio recordings available for training conversational AI systems. Creole languages are considered low-resource due to the shortage of these data. All creole languages are considered low-resource, including Papiamento.

Macaire et al. (2022) investigated the use of self-supervised models for two low-resource Creole languages, Gwadloupéyen and Morisien. They utilized a minor amount of available annotated data to develop an STT system and assess the amount of data required for a usable query by example system. They conclude that the development of a STT system for a low-resource language compared to its lexifier language proved to be more complex and inaccurate due to insufficient linguistic data. also evaluate the effectiveness of multilingual self-supervised models for Creole languages.

Keyword Spotting

KWS is an essential component in developing a STT system. However the vulnerability of self-supervised speech representations to adversarial attacks focusing on keyword spotting tasks could prove to be detrimental to applying this method when developing the STT. This has been research described by Guimarães et al.(2023). The significance of self-supervised learning in extracting meaningful features from speech signals for various downstream applications is of great value. Many models have demonstrated remarkable performance in extracting universal speech representations. However, these models show vulnerabilities in speech recognition systems. Just recently adversarial attacks on self-supervised speech representations have been explored. Through experiments the impact of these attacks on the robustness of self-supervised speech models are being evaluated. The performance of these models under clean conditions is compared with their performance under various adversarial attacks. The results indicated that there were significant drops in keyword spotting accuracy under these attacks. This emphasizes the need for improving their robustness in real world applications. After learning what types of attacks exist and knowing what damage they can deal to self-supervised speech representation systems, it can help prepare for future Papiamento self-supervised speech representation systems especially, with the help of keyword-spotting. This aspect is crucial when applying STT to critical components in healthcare systems.

Bushur and Chen (2023) demonstrated the complete process of developing a neural network for keyword spotting on edge devices. An edge device is a device that provides an entry point into enterprise or service provider core networks, for example routers, routine switches. Six neural network architectures were implemented and modified to meet the requirements of keyword spotting. These architectures were trained and quantized using the Google Speech Commands dataset, resulting in 350 different models. The performance of each model was evaluated based on various metrics such as model size, accuracy, memory consumption, and inference latency under different resource constraints.A straightforward process for designing, evaluating, and deploying keyword-spotting neural networks on microcontrollers was made. This approach can be extended to other applications beyond keyword spotting, such as visual wake words and anomaly detection.This can be incorporated in the design of STT for healthcare systems.

Smart Speakers in Safety-Critical Systems

Sunshine's (2021b) article covers the potential of smart speakers to contribute to improve human health. Sunshine (2021b) states smart speakers may have advantages, such as being cheaper than smartphones and other medical-grade equipment and provide general accessibility for users. Smart speakers can enhance chronic disease management, passively identify unwitnessed medical emergencies, detect subtle changes in human behavior and cognition, and enable remote monitoring of infectious respiratory diseases, all while preserving privacy. These facts are supporting evidence that there are advantages of implementing this type of technology in the healthcare system. Implementation of this technologies in Aruba's healthcare system, can contribute to improving healthcare results. There are three basic mechanisms that have to be incorporated into smart speakers to be able to interact with patients. The first being the ability of smart speakers to be intelligent conversational agents for example facilitating medication reminders, lab result retrieval, appointment management, and wellness tracking (Sunshine, 2021b). The second mechanism being that smart speakers should have the ability to classify medically relevant diagnostic sounds and be capable of identifying voice biomarkers for various health conditions (Sunshine, 2021b). The last mechanism is a contactless active sensing system using computer vision, sonar, or radar for physiologic monitoring. For example, detecting a fall of a patient, monitoring respiratory and heart rates, and identifying changes in activity levels.

Sunshine(2021b) addresses privacy concerns, emphasizing the need for secure storage and analysis of health-related data within Health Insurance Portability and Accountability Act (HIPAA) -compliant environments. Even with smart speakers having advantages, the three mechanisms that this article states are a good reminder of what these devices should minimally posses. An indispensable factor that should always be considered is having a proper privacy system. Sunshine's(2021b) article asserts that smart speakers can be implemented into Safety Critical Systems such as human healthcare. However, even with this potential, it requires collaboration between smart speaker manufacturers, regulatory bodies, and healthcare stakeholders to develop a robust ecosystem for medically oriented applications while prioritizing privacy preservation. These devices should have the Papiamento language already implemented to make this process more accessible. Especially, If Aruba plans to implement these systems, this requires intense collaboration between professionals from the healthcare and technology industries.

Clemente et al. (2022) researches the potential of implementing smart speakers with virtual assistants in healthcare. Advantages of these smart speakers are amongst others, improving health self-education and therapy adherence, emphasizing the simplicity, immediacy, and low cost of these tools.Implementation of these tools demands caution in particular when dealing with safety, the risk of incorrect advice and the possibility of over-reliance on virtual assistants. For this reason, Clemente et al. (2022) stresses the importance of user awareness. They suggest using constrained language for healthcare applications and emphasize that there should be some sense of validation by human specialists. Additionally, the topic of personal data security and privacy cannot be overlooked. Nonetheless, the potential of using virtual assistants in a healthcare environment can lead to improvement. Both articles emphasize that smart speakers have the potential to be implemented in the healthcare system. Incorporating the Papiamento language into these systems will increase acceptability and use of these smart speakers.

Conclusion

This review of literature has explored the development of a speech-to-text keyword model tailored for the Papiamento language, particularly within the context of our local healthcare environment. With the fact that Papiamento has approximately 200,000 speakers and is growing, it presents itself with an opportunity for technological integration, especially in emerging fields like voice assistant devices such as smart speakers. The major voice assistants currently support a plethora of international languages. However, Papiamento, like many other Creole languages remains overlooked. With the literature review, various aspects of the Papiamento language, similar language models, AI mechanics of keyword spotting, and the use of smart speakers in healthcare safety-critical systems have been examined, all of which provide valuable insights into crafting effective speech-to-text models. Applying machine learning to Papiamento is likely to present challenges similar to those that are relevant to other Creole languages, including both linguistic and societal characteristics. Furthermore, looking into keyword-spotting techniques and the potential of smart speakers in healthcare environments helped bring forth the importance of integrating Papiamento into such systems. Advancements in machine learning, particularly in neural network architectures, and understanding Papiamento's characteristics, could make it feasible to develop an accurate and efficient speech-to-text model for specific applications, such as voice commands in hospitals. While many main research questions could not be answered in this literature review, due to the unavailability of data regarding the application of Papiamento in technology in general and more specifically not as a speech-to-text recognition language, these questions are still crucial to successfully implementing a Papiamento speech-to-text healthcare keyword system. This requires minimally the creation of a Papiamento audio database for further practical experimentation. In short, the literature review does help fill in some gaps by integrating the Papiamento language into AI hardware and suggests that it will help preserve and promote the language for future generations. The proposed speech-to-text model holds promise in enhancing communication and accessibility within Papiamento-speaking communities, particularly in critical settings like healthcare.

References:

- Arends, J., Muysken, P., & Smith, N. (1995). *Pidgins and Creoles: An Introduction.* John Benjamins Publishing.
- Bushur, J., & Chen, C. (2023). Neural network exploration for keyword spotting on edge devices. Future Internet, 15(6), 219. https://doi.org/10.3390/fi15060219
- Clemente, C., Greco, E., Sciarretta, E., & Altieri, L. (2022). Alexa, how do I feel today? Smart speakers for healthcare and wellbeing: an analysis about uses and challenges. Soc. & Soc. Work Rev., 6, 6.
- *Etymologically*. (2024). https://dictionary.cambridge.org/dictionary/english/etymologically
- *Guimarães, H. R., Zhu, Y., Mengara, O., Avila, A. R., & Falk, T. H. (2023, October). Assessing the Vulnerability of Self-Supervised Speech Representations for Keyword Spotting Under White-Box Adversarial Attacks. In 2023 IEEE International Conference on Systems, Man, and Cybernetics (SMC) (pp. 1672-1677). IEEE.*
- Kester, E., & Buijink, S. (2023). Language use, language attitudes, and identity in Aruba. *Journal of Pidgin and Creole Languages (Print)*, 38(2), 389–430. https://doi.org/10.1075/jpcl.22010.kes
- Macaire, C., Schwab, D., Lecouteux, B., & Schang, E. (2022). Automatic speech recognition and query by example for Creole languages documentation. https://hal.science/hal-03625303/
- Mary, L., & Deekshitha, G. (2018). Keyword spotting techniques. In *SpringerBriefs in speech technology* (pp. 45–60). https://doi.org/10.1007/978-3-319-97761-4_4
- Schieferstein, S. (2018, December 11). Improving neural language models on low-resource Creole languages. https://www.ideals.illinois.edu/items/109530
- Sunshine, J. (2021b). Smart speakers, the next frontier in computational health. arXiv (Cornell University). https://doi.org/10.48550/arxiv.2103.04209 Summa Linguae. (2022, October 31). *Language support in voice assistants compared.* Summa Linguae. https://summalinguae.com/language-technology/language-support-voice-assistants-compared/
- *What is machine learning (ML)? | IBM.* (n.d.). https://www.ibm.com/topics/machine-learning

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I found myself continuously inspired.

During this experience, from the beginning I did not know what to expect. From the students from previous years and past symposiums I had an idea of the outcome but I was not expecting the process.

From before hand, all the way in Utrecht, I understood this would be something of a rather mental challenging course with engaging lectures, thought-provoking discussions, and collaborative activities. But through these challenges I gained invaluable insights into the subject matter at hand. Each class session was a chance to expand my understanding, challenge my assumptions, and broaden my perspective. I found myself continuously inspired by the depth of expertise shared by instructors, guest speakers and fellow students. Each contributing a unique perspective that enriched the learning environment.

However, what truly made this experience memorable and transformative for me was the connections forged along the way. These relationships went beyond just the subjects of school; they were built on a foundation of mutual respect, trust, and shared passions for making the world a better place.

As I reflect on this experience, I am filled with a sense of gratitude and pride for the knowledge that I have gained and for the connections I have made.

I could not have imagined having this experience and doing all of this with a more fun group of individuals.

You all hold a special place in my heart and I already can’t wait to see you again.

But on the topic of school subjects, I hope this report provides insight and inspiration for all who reads it, and in turn eventually help deliver additional findings in the future.

Mangrove Mapping and Conservation on Bonaire: A Comprehensive Study

Abigayle Domacassé

Introduction

Bonaire, an island nestled within the southern Caribbean sea, holds a unique ecological significance within the Caribbean Netherlands. Its unique blend of terrestrial and marine ecosystems harbors unparalleled biodiversity and ecological complexity (TEEB, n.d.). At the heart of this ecological mosaic lie the mangrove forests, which play a pivotal role in shaping the island's coastal landscapes and supporting its vibrant marine life (Van Beukering et al, 2022).

Mangrove forests are some of the most biodiverse and productive ecosystems on Earth. They provide a wide array of ecosystem services essential for coastal communities and marine biodiversity (Thomas et al, 2017). In Bonaire, these coastal wetlands serve as vital nurseries and habitats for fish, crustaceans, and other marine organisms, strengthening the resilience of local fisheries and supporting livelihoods (Van Beukering et al, 2022). Mangroves also act as natural buffers against coastal erosion and storm surges, safeguarding shorelines and mitigating the impacts of climate change-induced hazards. Their intricate root systems trap sediments and filter pollutants, improving water quality and enhancing coastal resilience. Thus, the preservation and sustainable management of Bonaire's mangrove ecosystems are essential for the island's ecological integrity and coastal security (Van Zee, 2020).

Despite their ecological significance, Bonaire's mangrove ecosystems face growing threats from human activities, climate change, and habitat degradation (Casal et al, 2024). Comprehensive mapping and spatial analysis of mangrove habitats are essential for understanding their distribution, structural attributes, and ecological dynamics. Mapping and spatial analysis can make use of remorse sensing techniques, geographic information systems (GIS), and possible field surveys (Sunkur et al, 2024)

This proposed project aims to generate detailed maps of Bonaire's mangrove forests, explaining their spatial extent, species composition, and habitat connectivity. Such mapping endeavors are necessary for identifying priority areas for conservation, assessing habitat fragmentation, and monitoring changes in mangrove extent over time. In addition, mapping provides valuable insights for informed decision-making and adaptive management strategies aimed at preserving Bonaire's mangrove ecosystems for future generations.

Literature Review

Mangroves, characterized by their unique adaptation to coastal environments, serve as critical ecosystems worldwide, providing a wide array of ecological, economic, and societal benefits. This literature review explores the ecological importance of mangroves, global conservation efforts, and previous studies on mangroves in Bonaire to provide context for the current research on mangrove mapping and conservation in the region.

Mangrove forests are renowned for their ecological significance, acting as vital buffers between terrestrial and marine environments. These coastal wetlands serve as crucial habitats for a diverse array of flora and fauna, including fish, crustaceans, mollusks, and birds. The intricate root systems of mangroves provide nurseries and shelter for juvenile fish and other marine organisms, contributing to the productivity and resilience of coastal fisheries (Lewis & Gilmore, 2007). Furthermore, mangroves play a key role in carbon sequestration, storing vast amounts of carbon in their biomass and sediments, thereby mitigating climate change (Alongi, 2014). Their dense root networks stabilize shorelines, reduce erosion, and protect coastal communities from storm surges and flooding events. Additionally, mangroves act as nutrient filters, trapping sediments and pollutants, and improving water quality in adjacent marine ecosystems (The Nature Conservancy, 2020).

Global Mangrove Conservation Efforts

Recognizing the ecological importance of mangroves, international organizations, governments, and non-governmental organizations (NGOs) have spearheaded conservation initiatives to protect and restore mangrove ecosystems worldwide (Global Mangrove Alliance, 2018). The Ramsar Convention on Wetlands, established in 1971, designates mangrove habitats as wetlands of international importance, encouraging member states to conserve and sustainably manage these ecosystems (The Ramsar Convention, 2016). The United Nations Sustainable Development Goals (SDGs), particularly Goal 14 (Life Below Water) and Goal 15 (Life on Land), emphasize the importance of mangrove conservation for biodiversity conservation, climate change mitigation, and sustainable development (United Nations, 2016). Furthermore, regional initiatives such as the Global Mangrove Alliance and the International Union for Conservation of Nature (IUCN) Mangrove Specialist Group work collaboratively to promote mangrove conservation, research, and capacity-building efforts worldwide (Global Mangrove Alliance, 2023).

Previous Studies on Mangroves in Bonaire

Several studies assess the status, distribution, and ecological dynamics of mangroves in Bonaire, shedding light on their importance and vulnerabilities. Verweij et al (2020) conducted a comprehensive study on the nature, economy, and tourism of Bonaire, highlighting the ecological significance of mangroves and their role in supporting biodiversity and coastal resilience. The Dutch Caribbean Nature Alliance (DCNA) (2011) assessed the threats to mangrove ecosystems in Bonaire, identifying habitat degradation, pollution, and climate change as primary concerns. Additionally, research by local conservation organizations, such as STINAPA Bonaire and the Bonaire National Marine Park, has focused on monitoring mangrove health, conducting habitat assessments, and implementing restoration projects to conserve these critical ecosystems (STINAPA, N.A.).

Overall, the literature highlights the ecological importance of mangroves, global conservation efforts to protect these vital ecosystems, and previous research on mangroves in Bonaire. Building upon this foundation, the current research aims to contribute to the conservation and sustainable management of mangroves in Bonaire through comprehensive mapping and spatial analysis, informed by ecological insights and global best practices in mangrove conservation.

Methodology

Using the information and methods from the studies previously done by Wang et al (2019), Casal et al (2024), Thomas et al (2017), and Debrot et al (2010), the following strategies have been adopted.

The starting point for data collecting is considering accessibility, ecological diversity and conservation importance in order to identify the area that is to be studied. In the case of Bonaire, this would be the Lac Bay area which has been known as the mangrove habitats area for generations (Tourism Corporation Bonaire, N.A.).

The remote sensing data collection process entails first getting high resolution satellite imagery covering the study area, in order to ensure optimal temporal and spectral resolution for mangrove mapping (Mårtensson, 2011). If available, it would also be helpful to obtain LiDAR data to provide additional information for more accurate mapping of the structure and biomass of the mangroves. Some extra steps that can be done for more enhanced imagery, delivering a more reliable outcome are geometric correction, radiometric calibration, and atmospheric correction of satellite imagery. These efforts have minimized atmospheric effects, ensuring reliable analysis outcomes (Habib, et al. 2011).

Relevant remote sensing-based approaches employ techniques such as supervised and unsupervised classification, spectral indices, and change detection analysis to assess mangrove ex tent, fragmentation, and dynamics over time. Additionally, advances in remote sensing have facilitated the development of predictive models to understand the drivers of mangrove change and forecast future trends under different scenarios (Tran, Reef & Zhu, 2022).

Different classification techniques are then used to categorize satellite imagery into various land cover classes, including mangroves, water bodies, vegetation types, and built-up areas. Spectral indices can then be employed to differentiate mangrove vegetation from the other land cover types, enabling assessment of its health and vitality. Object-based image analysis (OBIA) can be conducted to delineate individual mangrove patches, evaluating their spatial distribution, size, and connectivity for a comprehensive understanding of mangrove ecosystems. The results obtained from this are to be validated through field surveys by comparing the images and field observations. These observations are measured using GPS and field mapping tools, to record the vegetation characteristics and document the potential impacts on mangrove ecosystems, facilitating a holistic understanding of mangrove dynamics (Mårtensson, 2011).

After collecting the data, the remote sensing-derived mangrove maps integrated with field data and ancillary information will generate comprehensive datasets for analysis, enabling a detailed assessment of the extent, distribution, and fragmentation of the mangroves. Spatial analysis using GIS tools quantifies mangrove characteristics such as extent, distribution, fragmentation, and proximity to human settlements, protected areas, and potential sources of anthropogenic impacts.

Temporal changes in mangrove extent and health are to be assessed using multi-temporal satellite imagery and change detection techniques, identifying areas of mangrove loss, gain, or degradation over time. Information about events that have influenced the mangroves' health is an important piece of the puzzle: How did the mangroves get into the state they are currently in? The way to acquire this data is by engaging with local stakeholders, including government agencies, NGOs, community groups, and indigenous communities that have experience and knowledge about the mangroves. Engaging with stakeholders throughout the research process can help foster their collaboration, exchange knowledge, and co-production of actionable insights about the existing mangrove conservation and management (Global Mangrove Alliance, 2023).

Anticipated Outcomes

Successful execution of the proposed methodology for mapping and monitoring mangrove ecosystems in Bonaire has a number of potential outcomes. The research would yield high-resolution maps depicting the spatial extent, distribution, and structural characteristics of mangrove ecosystems in Bonaire. These maps would provide valuable insights into the location and health of mangrove habitats, facilitating informed decision-making for conservation and management purposes.The mapping would also identify priority areas for mangrove conservation and restoration efforts based on ecological significance, biodiversity value, and vulnerability to anthropogenic impacts. These areas could serve as focal points for targeted conservation interventions and habitat restoration initiatives.

By integrating the remote sensing data with field observations, the research would enable the assessment of mangrove health and vitality, including indicators of species composition, canopy structure, and ecosystem functioning. This information would help monitor changes in mangrove condition over time and evaluate the effectiveness of conservation measures. The analysis of the remote sensing data and field surveys would provide insights into the extent and magnitude of anthropogenic impacts on mangrove ecosystems, such as coastal development, pollution, and habitat degradation. This understanding would inform strategies for mitigating human-induced threats and promoting sustainable land-use practices.

Collaborating with local stakeholders, including government agencies, NGOs, community groups, and indigenous communities, would foster knowledge exchange, capacity-building, and stakeholder engagement in mangrove conservation and management efforts. Empowering local communities with the skills and resources to monitor and protect mangrove ecosystems which is critical for long-term sustainability. The research findings could also lead to informed evidence-based policy and management recommendations aimed at enhancing the conservation and sustainable management of mangrove ecosystems in Bonaire. These recommendations could include measures to strengthen protected area management, regulate land use, and promote community-based conservation initiatives.

Overall, the execution of the proposed methodology would contribute to a better understanding of mangrove ecosystems in Bonaire and further support efforts to conserve these valuable coastal habitats for future generations.

Conclusion

The intricate mangrove ecosystems of Bonaire stand as a testament to the island's rich ecological heritage and vital role in sustaining both terrestrial and marine life. As highlighted throughout this study, mangroves are not merely a collection of trees; they are dynamic ecosystems that serve as the lifeblood of coastal communities, support biodiversity, and play a pivotal role in climate resilience. With the methodology, drawing upon a wealth of prior research and employing advanced remote sensing techniques, promises to deliver detailed insights into the spatial distribution, health, and dynamics of Bonaire's mangroves. The anticipated outcomes of this research, from high-resolution maps to informed policy recommendations, hold the potential to revolutionize mangrove conservation efforts on the island.

In conclusion, the preservation and sustainable management of Bonaire's mangrove ecosystems are not just a matter of ecological conservation but also a testament to our commitment to future generations. Through concerted efforts and collaborative approaches, we can ensure that these invaluable coastal habitats continue to thrive, benefiting both nature and people alike. Let us embrace this opportunity to protect and cherish Bonaire's mangroves, ensuring their legacy for generations to come.

References

- Alongi, D.M. (2014). Carbon sequestration in mangrove forests. *Carbon management*. 3(3). 313-322. DOI:10.4155/cmt.12.20
- Casal G, Tregarot E, Cornet C, McCarthy T, van der Geest M. (2024). A cost-effective method to map mangrove forest extent, composition and condition in small islands based on Sentinel-2 data: Implications for management. Ecological Indicators, Volume 159, 111696, ISSN 1470-160X, https://doi.org/10.1016/j.ecolind.2024.111696.
- Dutch Caribbean Nature Alliance (DCNA). (2011). *Healthier Mangrove Key in Managing Our Carbon Footprint.* https://dcnanature.org/mangroves-carbon-footprint/
- Debrot A.O, Meesters E, De Leon R, Slijkerman D. (2010). *Lac Bonaire - Restoration Action Spear Points, September 2010.* https://edepot.wur.nl/155336
- Global Mangrove Alliance. (2018). *About Us: Learn more about the history and goals of the Global Mangrove Alliance.* https://www.mangrovealliance.org/about-us/
- Global Mangrove Alliance. (2023). *Including Local Ecological Knowledge in Mangrove Conservation & restoration.* https://www.mangrovealliance.org/wp-content/uploads/2024/02/LEK-Guide-Master-Book_Final.pdf
- Habib, A. et al (2011). Geometric Calibration and Radiometric Correction of LiDAR Data and Their Impact on the Quality of Derived Products. *Sensors 2011, 11*(9), 9069-9097. DOI: https://doi.org/10.3390/s110909069
- Lewis III R.R. & Gilmore Grant R. (2007). IMPORTANT CONSIDERATIONS TO ACHIEVE SUCCESSFUL MANGROVE FOREST RESTORATION WITH OPTIMUM FISH HABITAT. *Bulletin of Marine Science. 80*(3). 823-837.
- Mårtensson, U. (2011). Introduction to Remote Sensing and Geographical Information Systems. https://www.nateko.lu.se/sites/nateko.lu.se.sv/files/remote_sensing_and_gis_20111212.pdf
- STINAPA. (N.A.). *Mangroves*. https://stinapabonaire.org/nature-projects/mangroves/
- Sunkur R, Kantamaneni K, Bokhoree C, Rathnayake U, & Fernando M. (2024). *Mangrove mapping and monitoring using remote sensing techniques towards climate change resilience.* https://www.nature.com/articles/s41598-024-57563-4#:~:text=Mapping%20the%20natural%20extent%20of,provide%20data%20on%20the%20evolutionary
- TEEB Caribbean Netherlands. (n.d.). *What is Bonaire's Nature worth?*. https://nl.chm-cbd.net/sites/nl/files/2021-07/Whats%20Bonaires%20Nature%20Worth.pdf
- The Nature Conservancy. (May 04, 2020). *The importance of Mangroves.* https://www.nature.org/en-us/about-us/where-we-work/united-states/florida/stories-in-florida/why-mangroves-important/#:~:text=Their%20above%2Dground%20roots%20slow,the%20estuarine%20and%20ocean%20environment.
- The Ramsar Convention. (2016). *The Ramsar Convention: what's it all about.* https://www.ramsar.org/sites/default/files/fs_6_ramsar_convention.pdf
- Thomas N, Lucas R, Bunting P, Hardy A, Rosenqvist A, Simard M. (2017). Distribution and drivers of global mangrove forest change, 1996-2010. PloS ONE 12(6): e0179302. https://doi.org/10.1371/journal.pone.0179302
- Tran, T.V., Reef, R. & Zhu, X. (2022) A Review of Spectral Indices for Mangrove Remote Sensing. *Remote Sens. 2022, 14*(19), 4868. DOI: https://doi.org/10.3390/rs14194868
- Tourism Corporation Bonaire. (N.A.). *Mangroves east* https://bonaireisland.com/experiences/sightseeing/sites/mangroves/
- United Nations. (2016). *The 17 goals.* THE 17 GOALS | Sustainable Development (un.org)

- Van Beukering, P., et al. (2022). *The impacts of climate change on Bonaire.* Retrieved from: https://www.greenpeace.org/static/planet4-netherlands-stateless/2022/10/47b4d204-bonaire-klimaatverandering-ivm_r22-06_synthesis-report-2022-1.pdf
- Van Zee, R. (July 2020). *The role of creeks for tidal exchange in the mangrove forest of Lac Bay, Bonaire.* https://www.utwente.nl/en/et/cem/research/wem/education/msc-thesis/2022/zee.pdf
- Verweij, P., et al. (2020). *A nature inclusive vision for Bonaire in 2050.* https://library.wur.nl/WebQuery/wurpubs/fulltext/526467
- Wang et al. (2019). A review of remote sensing for mangrove forests: 1956-2018. (2019). Remote sensing of Environment, 231,DOI: https://doi.org/10.1016/j.rse.2019.111223

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Life has presented its fair share of challenges.

Reflecting on my journey since the beginning of the SISSTEM program, life has presented its fair share of challenges, yet none quite as formidable as the ones I have endured this past year.

Being a third year student, a senior, on its own is already very stressful. But having to juggle doing your thesis alongside multiple course assignments, presentations, projects and not being able to attend lectures because you have other commitments is enough to drive someone crazy. That is me, I'm that someone.

However, I have learned and more importantly accepted the fact that I need to take a breather and calm down, so that I don't get too overwhelmed and anxious to the point where I'm not doing anything at all. Which has happened multiple times before.

The thing is when you think about how you won't be able to achieve or accomplish something before actually trying or to not bother trying at all because you *'know'* you wouldn't succeed, was one of my biggest reasons to almost throw in the towel.

But now I have realized that you have to push through and just start. Starting with something that you need to get done, be it a poster, project or paper, start by doing something - anything.

Even if it starts off sloppy and unprofessional or with random thoughts, taking things step by step helped me to check things off my to-do list and made me understand that I actually can do this.

I do admit that it is not always easy to enter this mindset especially when you're exhausted and done with everything, but that's where the *'push through'* comes in. Life doesn't always give you what you want, but what you've worked for. And even though that's a hard pill to swallow, it's also my motivation to keep working hard for the things that I want, and one thing that I really want is this degree.

Uncovering the Relationship Between Urbanization, Forest Clearance, and Urban Heat Islands, Aruba

Shanisse M. Franken

Abstract

Tropical dry forests, although they provide protection for thousands of species, food, medicine and livelihoods, are not shown the same value of importance in comparison to tropical rainforests and thus fall victim to deforestation in many countries, and Aruba is no exception. Most forest clearance in Aruba makes room for building construction, with the purpose of supporting increased housing, job or tourism demands. Construction activities have negative effects on the environment, such as soil alteration, emissions, replacing grass with asphalt, and as a consequence resulting in the formation of urban heat islands that cause thermal discomfort, illnesses and possible death. Therefore, it is valuable to explore whether deforestation and forest clearance cause the formation of urban heat islands in relationship with land surface temperatures (LST) in Aruba.

Introduction.

Forests are essential for healthy living conditions. Many believe that the most threatened tropical forests are tropical rainforests (Janzen, 1988). Meanwhile, tropical dry forests are overlooked because they don't support many species or have high carbon stocks compared to rainforests. Still, the preservation and protection of tropical dry forests will protect thousands of species, and provide millions of people worldwide with food, medicines, and livelihoods (Ghose, 2020). Although tropical dry forests provide many benefits, more than 71 million hectares of tropical dry forests have been lost since the innovative approach to deforestation took place in the 2000s (Baumann et al, 2022). Reasons for tropical dry forest deforestation vary between countries. Some deforestation actions take place due to population growth or to expand agriculture, urbanization, cities, manufacturing, and industrial sites, among other reasons (DGB Group, 2023).

Urban development activities such as replacing grass with asphalt, replacing trees with buildings and towers, releasing artificial heat from human activities into the atmosphere, and preventing surface infiltration by disposing of rain through drains, gutters, and sewers contribute to the formation of urban heat islands (Abdullah, 2010). People with low endurance capabilities can experience illnesses as well as death due to the effects of urban heat islands (Nuruzzaman, 2015).

Aruba, the small Caribbean island where this research is to be conducted, is home to tropical dry forests that are being threatened with deforestation due to rising demands of population growth, tourism, and urbanization. This threat not only endangers Aruba's tropical dry forests but also its local flora and fauna species, including species protected by the law. It is also important to establish whether urbanization and forest clearance practices have caused and/or formed urban heat islands on Aruba. Urbanization is defined as the replacement of natural landscapes with buildings, roads and parking lots, while urban heat islands (UHIs) are phenomena in which urban areas are warmer than either surrounding or an equivalent areas that are not urbanized.

Little research has been conducted in Aruba on the relationship between urbanization, forest clearance, and urban heat islands. The main research question of this proposed study is thus 'Does urbanization and forest clearance form urban heat islands in Aruba?' The research design for this study is to collect land surface temperature (LST) using spatial data, mainly during the dry season with Google Earth Engine. I hypothesize that Aruba does contain urban heat islands, especially in the Oranjestad district, where there is an abundance of buildings, consistent release of artificial heat into the atmosphere caused by human activities and low amount of vegetation coverage.

In order to answer the main research question, the following four sub-questions have been created: 1) How has land surface temperature (LST) vary in the last 10 years? 2) What is the relationship between the vegetation index and land surface temperature? 3) How does land surface temperatures vary between the vegetation index and urbanized areas? 4) How will the effects of urbanization on land surface temperature evolve over the next 10 years?

Literature Review.

Forests worldwide are responsible for climate stabilization, oxygen, nourishment, carbon removal, and maintaining and supporting flora and fauna. A study conducted by Coe et al (2022) that reviewed the biophysical effects of deforestation, such as albedo, evapotranspiration (ET), and canopy roughness, shows that forests assist in moderating local temperature conditions, provide cooling during hot weather, minimizes risks due to drought by dissipating heat and transporting moisture into the atmosphere, as well as influencing the formation of clouds which increases albedo and promote rainfall. With regularly increasing population growth there is constant action being taken toward forest clearance with the purpose of constructing and supporting rising housing and job demands, which not only releases trapped carbon back into the atmosphere but also affects the soil properties. For instance, a study conducted by Bouchantouf et al (2022) that researched the effects of deforestation followed by cultivation, stated that healthy forests provide good soil cover, enrich soil organic matter, and improve soil stability, while deforestation increases the effects of climate change, negatively impacts the structural stability of the soil, reduces the soil fertility with 7% which leads to changes in the physical and biological properties of the soil, and increases the possibility of erosion.

Changes in land use caused by urbanization can, furthemore, modify the energy balance and affect the urban thermal environment, and in turn form urban heat islands (UHIs) (Yoo, 2018).The formation of urban heat islands depends on the contribution of various factors, but some of the main contributors are "vegetation and evapotranspiration reduction, presence of dark surfaces with low albedo, increased anthropogenic heat production" (Rupard, 2019) and temperature increase due to rapid urbanization activities that leads to excessive heat production (Ibrahim et al, 2017).There are also other factors that contribute to the occurrence and intensity of urban heat islands. For instance, weather conditions that maximize the amount of solar energy that reaches urban surfaces, the geographic location which has an influence on the climate, the time of day and season which can affect the temperature frequency and magnitude of urban-rural areas, the city size and shape that "affects the magnitude of urban heat island effects", city form that exposes urban surfaces to solar radiation and city function that increases the temperature through energy use and heat production caused by human activities (Rupard, 2019). Moreover, buildings and streets that block heat loss and wind circulation, city building materials that retain heat, human activities that release heat, and polluted atmosphere will also contribute to the formation of urban heat islands (Abd.Latif et al, 2013).

The formation and presence of urban heat islands pose various challenges for human residents and the natural environment. Al-Hameedawi et al (2023) explained that extreme hot or cold weather can worsen respiratory or cardiovascular diseases and increase the possibility of death, as well as cause nasal bleeding due to lack of air zones and high pressure, thermal discomfort, and the surface urban heat island intensity (SUHIs) caused by thermal pollution damages the water quality which impacts aquatic life, specifically the metabolism and reproduction system of various aquatic species.

Additionally, the rising temperature can cause heat stress, leading to an increase in energy consumption in order to cool buildings and decrease thermal discomfort resulting in higher energy demand, burning of fossil fuels, and greenhouse gas emissions (Kara et al, 2022).

There are, fortunately, possible solutions to mitigate the effects of urban heat islands by integrating cooling techniques, such as promoting natural ventilation, using high-albedo materials on building surfaces, using white pavement instead of asphalt, using cool roofs, and incorporating vertical and horizontal green spaces (Abdullah, 2011).

Lastly, Liu and Liu (2012) discusses how increasing vegetation coverage will lessen the effects of urban heat island since green plants can absorb and control CO2 , increase air humidity, reduce temperature, and impair solar radiation.

Methodology

In the proposed study, I will investigate whether urbanization and forest clearance lead to the formation of Urban Heat Islands (UHIs). Again, the research will be broken down into four sub-questions: 1) How has land surface temperature (LST) vary in the last 10 years? 2) What is the relationship between the vegetation index and land surface temperature? 3) How does land surface temperatures vary between the vegetation index and urbanized areas? and 4) How will the effects of urbanization on land surface temperature evolve over the next 10 years?
To collect spatial data regarding Aruba's land surface temperature (LST) during the dry season (approximately from September 30th to February 1st), Google Earth Engine will be used to replicate the tutorials by Chakraborty (n.d.) and Ramadhan (n.d) and to analyze the relationship between land surface temperature and urban heat islands.
For the purpose of organizational outline, this methodology is subdivided into five sections corresponding to one of the four sub-questions, where sub-question 1 corresponds to section 1, sub-question 2 corresponds to section 2, sub-question 3 corresponds to section 3 and 4, and sub-question 4 corresponds to section 5.

In section 1, 10 years' worth of LST data will be loaded from the MODIS satellite for Aruba during the dry season, where all water pixels will be masked out to avoid collecting data that is being altered due to the presence of clouds. Section 2 will map out the normalized difference vegetation index (NDVI) for each pixel so that we can see Aruba's vegetation. Section 3 will separate the rural land from urban land. Section 4 will calculate the surface urban heat island intensity between urban and rural land, and section 5 will predict how the LST of Aruba will be in 10 years using the 2013-2023 LST data as a guide.

The sections are as follows:

Section 1. Deriving Land Surface Temperature.

- Load feature collection data of Aruba from the MODIS satellite;
- Define an error margin;

- Set map center and zoom level;
- Add layer to map;
- Load MODIS MYD11A2 version 6 product from the Earth Engine data catalog;
- Select band of interest;
- Create a filter from February 1st to September 30th;
- Create a date range filter for 10 years;
- Take pixel-wise mean of all the images collected;
- Convert LST of the images into Celsius;
- Mask out all water pixels;
- Clip data to region of interest;
- Add layer to map.

Section 2. Deriving Land Surface Temperature and Normalized Difference Vegetation Index from Landsat.

- Filter out cloudy pixels;
- Add a cloud score band to the image;
- Create an image mask from the cloud score band and apply it to the original image;
- Load the collection, apply cloud mask, and filter to date of interest;
- Generate median composite;
- Select Thermal band 10;
- Calculate normalized difference vegetation index (NDVI) from Landsat surface reflectance;
- Calculate fractional vegetation;
- Calculate emissivity;
- Calculate LST from emissivity and brightness temperature.

Section 3. Defining Urban and Rural References.

- Subtract the original urban cluster from the buffered cluster;
- Generate rural cluster.

Section 4. Calculating the Surface Urban Heat Island Intensity (SUHI).

- Define a function to reduce region and summarize pixel values;
- Calculate the spatial mean value of LST for each case;
- Make sure all pixel values are in Celsius;
- Map the function over the constant buffer rural reference boundary;
- Map the function over the standardized rural reference boundary.

Section 5. Predicting LST over time.

- Load LST data from 2013-2023;
- Define a region of interest;
- Add Shuttle Radar Topography Mission to help with the prediction;
- Create a change map;
- Create variables to help predict LST;
- Create a sample data;
- Split into train and test data;
- Build a random LST model prediction;
- Test the model accuracy;
- Create variables to predict 10 years into the future (from 2023 to 2033);
- Calculate LST per year.

Conclusion

In conclusion, as the demand for urbanization and deforestation continues to increase, land surface temperatures keep rising and the formation of urban heat islands keeps on growing causing various challenges to those living in them. Therefore, it is important to research if urban heat islands are forming in Aruba, and perhaps as a follow-up research, what could be possible solutions to mitigate its effect in a country such as Aruba that is consistently experiencing the hot summer season.

References

- Abd.Latif, Z., Chan, A., Mohd, W. & Salleh, S. (2013) Factors Contributing To The Formation Of An Urban Heat Island in Putrajaya, Malaysia. *Procedia Social and Behavioral Sciences.* https://core.ac.uk/download/pdf/82540614.pdf
- Abdullah, N.A.G., Che-Ani, A.I., Maulud, K.N.A., Shahmohamadi, P. & Tawil, N.M. (2011) The Impact of Anthropogenic Heat On Formation of Urban Heat Island and Energy Consumption Balance. *Hindawi Publishing Corporation.* doi:10.1155/2011/497524
- Abdullah, N.A.G., Che-Ani, A.I., Maulud, K.N.A., Mohd-Nor, M.F.I., Shahmohamadi, P & Tahir, M.M. (2010) The Link Between Urbanization and Climate Factors: A Concept on Formation of Urban Heat Island. ISSN:1790-5079
- Al-Hameedawi, A., Hamoodi, M. & Jabbar, H. (2023) Urban Heat Islands: A review of Contributing Factors, Effects, and Data. *IOP Conference Series: Earth and Environmental Science.* https://iopscience.iop.org/article/10.1088/1755-1315/1129/1/012038/pdf
- Baumann, M., Buchadas, A., Kuemmerle, T. & Meyfroidt, P. (2022) Uncovering major types of deforestation frontiers across the world's tropical dry woodlands. *Nature Sustainability.* https://dial.uclouvain.be/pr/boreal/object/boreal%3A262259/datastream/PDF_01/view
- Bouchantouf, S., El Mazi, M., Hmamouchi, M., Houari, A., & Saber, E. (2022) Deforestation Effects on Soil Properties and Erosion: A Case Study In The Central Rif, Morocco. *Eurasian Journal of Soil Science, 11*(4), 275–283. https://doi.org/10.18393/ejss.1098600
- Chakraborty, T.C. (n.d.). Human Applications: Heat Islands. Retrieved from https://google-earth-engine.com/Human-Applications/Heat-Islands/
- Coe, M., Lawrence, D., Vandecar, K., Verchot, L., & Walker, W. (2022). The Unseen Effects of Deforestation: Biophysical Effects on Climate. *Frontiers in Forest and Global Change, 2-7.* https://www.frontiersin.org/articles/10.3389/ffgc.2022.756115/full
- DGB Group. (2023) Top 10 Causes of Deforestation. https://www.green.earth/blog/top-10-causes-of-deforestation
- Ghose, J. (2020). The Case for Conserving Tropical Dry Forests. *Yale Environment Review.* https://environment-review.yale.edu/case-conserving-tropical-dry-forests
- Ibrahim, M.H., Isa, N.K.M., Ismail, K. & Latiff, N.A.A. (2017) Effect of Urbanization Activities Towards The Formation of Urban Heat Island in Cameron Highlands, Malaysia. *IOP Conference Series: Earth and Environmental Science.* https://iopscience.iop.org/article/10.1088/1755-1315/148/1/012022/pdf
- Janzen, D.H. (1988) Tropical Dry Forests The Most Endangered Major Tropical Ecosystem. *National Library of Medicine.* https://www.ncbi.nlm.nih.gov/books/NBK219281/
- Kara, T., Rao, A. & Sinha, J. (2022) Urban Heat Island; Its Effect On Environment. *Research Gate.* https://www.researchgate.net/profile/Ajay-Adarsh-Rao-2/publication/358285438_Urban_Heat_Island/links/61fba3eeaad5781d41c9b9c9/Urban-Heat-Island.pdf?origin=publication_detail&_tp=eyJjb250ZXh0Ijp7ImZpcnN0UGFnZSI6InB1YmxpY2F0aW9uIiwicGFnZSI6InB1YmxpY2F0aW9uRG93bmxvYWQiLCJwcmV2aW91c1BhZ2UiOiJwdWJsaWNhdGlvbiJ9fQ
- Liu, H. & Liu, Q. (2012) The Urban Heat Islands Analysis; Factors of Building Surface, Green Area and Lighting. https://www.diva-portal.org/smash/get/diva2:567979/FULLTEXT01.pdf
- Nuruzzaman, M. (2015) Urban Heat Island: Causes, Effects, and Mitigation Measures - A Review. *SciencePG Science Publishing Group.* https://www.researchgate.net/profile/Md-Nuruzzaman-12/publication/283507719_Urban_Heat_Island_Causes_Effects_and_Mitigation_Measures_-A_Review/links/563c573708ae34e98c485eb0/Urban-Heat-

Island-Causes-Effects-and-Mitigation-Measures-A-Review.pdf

- Ramadhan (n.d.) Retrieved from: https://code.earthengine.google.com/6087fc6a48f426f2796fb664f1471b11
- Rupard, M. (2019) Urban Heat Islands: Causes, Impacts, & Mitigation. *California Polytechnic State University San Luis Obispo.* https://core.ac.uk/reader/219382030
- Yoo, S. (2018) Investigating Important Urban Characteristics in the Formation of Urban Heat Islands: A Machine Learning Approach. *Journal of Big Data.* https://journalofbigdata.springeropen.com/counter/pdf/10.1186/s40537-018-0113-z.pdf

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I have spent this time meeting people I would never have otherwise.

I find that I have trouble writing a summary of my time here on Aruba. My experience has been, well, mixed. A couple weeks ago, a bright-eyed US student, fresh off the plane, asked me if I was having 'sooo much fun?' on Aruba. Unfortunately, my reply was 'No, I actually thoroughly dislike this place'. I had real reasons for this answer. For the 2.5 months that I have been here, I have been constantly overheating; my great friend the sun has turned to an enemy. All of the things I do for fun and relaxation 'back home' have been made into stressful events here; any run has to be finished before 7:30 without breakfast, and I have been chased and threatened by dogs on about 1/3 of my runs. Idem dito for biking- I bravely set out to conquer this island on a little mountain bike, but this has proven to be both supremely difficult as well as unsafe – I have, almost unsurprisingly, been hit by a car during my time here. And again, the dogs chasing me into traffic and forcing me to divert my routes were decidedly not a bonus. Walking – one of my favourite activities – suffers from the same problems. Finally, I have found that being on an island this size, and having any movements made this difficult, I have felt trapped here in a way I have not felt anywhere else. That night, with the American student, I really did feel very negatively about the place where I had landed – I must apologise to any Aruban reading this, but I did.

While writing this, of course I have to make space for some reconsideration. I have spent this time meeting people I would never have otherwise, as well as meeting a culture I would never have otherwise. You might hear me speak negatively about road safety, but never about Arubans – they have been absolutely delightful and have set an example I have decided to follow, especially when it comes to hospitality and generosity. I have seen a country characterised by a wildly different landscape from the ones I know, populated by birds and lizards more colourful than I have ever encountered. I've had the privilege to dive amongst live reefs with fish in the strangest of shapes. I've had a couple of new foods. Of course, I have also learned in-depth about wondrous things like islandness, smallness, SDG's, Wicked Problems, circular opportunities and science-policy interfaces. I am grateful to our teacher, Eric Mijts, for guiding us through it all with so much interest, dedication and enthusiasm. In the end, I have learned a thing or two about myself as well; I have seen strength I hadn't expected and discovered new weaknesses, and I now know that I am to be very grateful for a temperate climate indeed. Thank you, Aruba, for having me. (But I will only ever return for those that inhabit you (and the wonderful avocados).)

The Building Blocks of Resistance against Same-Sex Marriage on Aruba

Veere Boucher

Introduction

Today, a woman cannot get married to a woman on Aruba. This year, something is going to change about that. Supposedly against the will of the government – possibly against the will of a substantial part of the Aruban population. What exactly is going on? Though over the years, some initiative has been shown from politicians, it was local humanitarian organisations which have taken the crucial step of following the legal rather than democratic route to legalisation of same-sex marriage, with success. However, local religious organisations, citizens and politicians are very vocally opposed.

The purpose of this paper will be to investigate what the *building blocks* of this resistance are - what are the elements that explain the reluctance from Arubans towards same-sex marriage (S-SM)? Defining these ‘blocks’ should visualise the wall blocking marriage equality - one that might still be worth toppling once S-SM has been implemented, as opinions and behaviours do not change overnight. Having analysed individual elements might help in tackling them, for example through education and awareness campaigns, as well as more specific interventions.

This paper will consist of 4 sections; one where I explain what the history of the debate surrounding S-SM is; a literature review in which I will theorise on what these building blocks might consist of; a short methods section, and finally my (preliminary) results.

Aruba – State of the Art

In this section I will summarise the history and current status of same-sex marriage and the perception of it and LGBT persons on Aruba. I am drawing on online news articles as well as some interviews and personal conversations I have had to reconstruct this history.

The discussion around same-sex marriage started when the Netherlands legalised this as the very first country in the world in 2001. The question of whether the other countries within the kingdom should follow suit immediately arose. In 2005, the problems that this legislative ‘split’ would cause presented itself when a Dutch same sex married couple requested the right to be considered married on Aruba, as they were running into problems. This case was closed in 2007 by the Joint Court of Justice. (Parool, 2007) Both the political and social climate proved to be hostile to the development, as illustrated by then-Minister of Justice Rudy Croes, who called this ruling a ‘black day for Aruba’. (Mirjam, 2005)

5 years later, there had been little change in this attitude, then-Prime Minister Mike Eman claiming that Aruba was not ready for a change on this front. (Caribisch Netwerk,

2013) Just a few years later, member of parliament Desiree Croes (AVP) entered an amendment for a registered partnership into the civil code of Aruba. (Caribisch Netwerk, 2015) This was followed by a period of extreme controversy within society as well as politics; Croes had to be protected by the police and experienced major workplace difficulties. In 2016, parliament agreed to enter the amendment into the civil code that was to replace the one from 2001. However, so much contention remained that the code – along with all other changes made to it – did not enter into practice until 2021, 5 years later. (Spier, 2019; Henriquez, 2021)

In 2019, Fundacion Orguyo was founded with the express purpose to get same-sex marriage legalised via the legal route, as the political route had failed or stalled. The foundation charged its government with violating anti-discrimination laws. LGBT individuals are protected in the Aruban constitution, yet they cannot marry. With this argument, Orguyo won their case in September 2021. The government went into appeal over this decision at the Joint Court of Justice, and lost again. Within a week, the Aruban government decided to go into appeal for a second time, now with the High Court of the Kingdom of the Netherlands, in the hope of retaining some political autonomy over this decision. (Nu.cw, 2022; Gaykrant, 2023)

This is an ongoing trial, and the concluding decision is expected on the 31st of May. The government's arguments aim to prove that it is not a judge's place to 'force' such a change on to society. It is argued that this society is not ready, mainly because it is very religious. It is the role of the politicians, as the chosen representatives of their citizens, to make this decision. Additionally, the European Court has said in an earlier ruling that the lack of a marriage option for same-sex couples is not necessarily considered discriminatory. Despite these arguments, it is expected that the High Court will stick to previous courts' conclusions and that thus, same-sex marriage will be legalised in 2024. (Drayer, 2022; Rijcken, 2024)

Politics on Aruba remain divided, while Accion21 and RAIZ have bonded together to push an unwilling parliament into deliberations about the legalisation of same-sex marriage. This debate is supposed to happen come May 8th, though many suspect it will end up being postponed. This might mean that the government could theoretically legalise S-SM before the court does, but this is not expected. (Aruba.nu, 2024)

Literature Review

The purpose of this literature review will be to examine what factors come forward in the literature as characteristics of societies and individuals that can predict or explain homonegativity. *['An aversion to homosexuality as a social practice or way of life'* (Jäckle, 2015)] These factors will then be related to Aruba based on what can be found in news articles, what has come forward in personal conversations, and in statistics collected by the Aruban government. The factors discussed are what we will consider potential building blocks of the resistance against same-sex marriage.

Individual characteristics

There has been a great number of studies into what characteristics and values of people are related to homonegativity. The first and most reliable characteristic of a person with a homonegative attitude tends to be their religiosity, measured by their frequency of church attendance and the importance they attach to religion in their lives. (Van den Akker, 2013; Gibert, 2024; Stulhofer, 2009; Withworth, 2023)

Other correlations that are frequently found: Those that earn less, are less educated, are men, are older, live outside the city, are married, hold conservative, authoritarian, and traditional values, have a lower trust in their environment and promote collectivism are more likely to express a homonegative attitude. (Jäckle, 2015; Leach, 2022)

Religion

Religion has consistently come forward as the single greatest predictor of homonegativity in both older and most recent research. Those that attribute greater significance to God in their lives, those that attend church more often, and those that describe themselves as religious tend to be more homonegative. These figures are further moderated by the general level of religiosity in a country; religious citizens of a heavily religious country tend to be less tolerant than the same churchgoers in a less religious environment. (Adamczyk, 2009; Jäckle, 2015; Reese, 2013)

Thus, it is likely that the opinions expressed by religious leaders as well as the religiosity of Aruba can be a factor in the resistance against S-SM. According to Aruba.com, over 75% of the population of Aruba identifies as Roman Catholic. There is little doubt about what the opinions expressed by church leaders encompass when it comes to this subject. In 2016, pastor Spilza of the Dakota church quite ominously warned his congregation that allowing same-sex marriage on Aruba would 'challenge God', in line with other homonegative trends in the Church over the years. (Caribisch Netwerk, 2016) In 2023, close to the hearing of the High Court about the same-sex marriage case, Christian groups on the island got together in marches in protest. Religious leaders handed over a petition with 18.000 signatures to the government, to show that the majority of the population did not want to 'open up marriage'. Pastor Norman Brown claimed at the time that marriage was between a man and a woman by God's design, and that the government should not 'normalise' other forms of marriage. (Stamper, 2023) Again, in March 2024, the churches of both Curacao and Aruba banded together to send a letter to the government not to obey the decisions of the High Court. Crucially, the organisations claimed to be speaking on behalf of the (majority of) the populations. (Antillaans Dagblad, 2024) The church as an organisation and church leaders as individuals on the islands are clearly and vocally opposed to S-SM, all the while claiming that their opinion reflects that of the population, positioning themselves as opinion leaders.

Masculinity

Some recent studies have found support for the idea that beliefs about gender have a great influence on homonegativity. In fact, in a 2008 study by Brown, adherence to traditional gender role beliefs was the single biggest predictor of this. Men tend to define themselves and their masculinity via a rejection of femininity. Gay men are usually seen as less masculine, and as such in violation of gender roles; this violation tends to then be punished by peers. (Meaney, 2010; Slaatten, 2014) Reese (2014) shows that male participants' social identity, in this case being their masculinity, is perceived to be threatened by gay men, triggering a negative reaction. This, along with the other research, shows that homonegativity may partially stem from a patriarchal male culture.

For the Aruban case, it may be fruitful to look into machismo culture, considering the geographic location of Aruba and its immigrant population. I adapt the definition of machismo given by Pena-Talamantes (2013) as being the conceptualisation of men and masculinity as dominant (over women and each other), aggressive, unemotional, and heterosexual. This version of masculinity is commonly associated with Latin, South-American cultures. Understandably, this expectation is harder for gay men to live up to; it is incompatible with the lived reality of gay men. There might be more pressure for macho heterosexual men to reject femininity and by association, gay men. Hirai (2014) indeed found that higher levels of machismo beliefs were associated with higher levels of prejudice against gays and lesbians.

Nationalism

Sremac and Ganzevoort (2015) describe the intertwined nature of sexuality, religion and nationalism and how this developed in several countries in EEU. For this thesis, I will use their definition of sexual nationalism as being *"Every perspective that links nationalism with a certain view of sexuality. [... where] the role of the state is invoked to regulate sexuality through restrictive politics (pro- or antigay discursive regimes) in the process of justifying national self-determination."* The definition of religious nationalism is more complicated; I will use a synthesis between Sremac's work and that of Mark Juergensmeyer (1996), where (ideological) religious nationalism is understood as a movement that attempts to religionize politics; where compatibility with religious goals becomes a criterion for an acceptable political platform, and that regulates views on and practices of that religion.

Going by aforementioned definitions, religious and sexual nationalism could be a factor in determining some of the homonegativity on Aruba. The reason most often cited by politicians in general and in the court cases for the lack of political will to legalise S-SM has been the idea that Aruba 'is a *Catholic country*' - note the difference with 'a country with a high population of Catholics'. (Gaykrant, 2023; Hendriksen, 2020) This is also illustrated by Marco Berlis and Hendrik Tevreden of the Aruban government explaining their decision to fight the court's initial judgement: *„Aruba is in overgrote meerderheid een Christelijk land. Het is autonoom en wil zijn eigen route bepalen" [Aruba is by large majority a Christian country. It is autonomous and wants to determine its own direction.]* The court has gone so far as to remind the lawyers of these countries in several instances that there ought to be a separation of the church and the state, signifying their belief that this is not fully the case at the moment. (Gaykrant, 2023) Also interesting to note is that the argument used in the most recent court case is that legalising S-SM infringes upon the religious rights of Arubans - meaning not only that the right to be opposed to S-SM on religious grounds is considered to be more important than the right to marriage equality, but also that religion is assumed to be inherently opposed to marriage equality. (Nu.cw, 2023) Finally, there is an explicit push from religious leaders on the island to influence politicians directly as well as indirectly, for example by rallying their constituents to put pressure on politicians to prevent same-sex marriage laws from coming into effect. (Caribisch Netwerk, 2016; NoticiaCla, 2024) In all of these cases, the contours of sexual and religious nationalism are present; the desire to have the state have a say in the expression of their citizen's sexuality, as well as the clearly apparent wish and intention - from both sides - to allow religion and the church have a say in the governance of Aruba. It is also clear what the impact of this variant of nationalism is, as those in power lose sight of the separation of church and state.

Post-coloniality

One factor that has come forward especially from news articles is the sense that same-sex marriage is a Western and especially *Dutch phenomenon*. From conversations on the island, it has become clear that there is a certain resistance against any form of Dutch influence. Though this has not been mentioned in personal conversations, I think the relationship with Aruba's coloniser is worth looking into in relation to my case study.

This reaction has been called *decolonial homophobia* by Day (2023); the idea that decolonisation and LGBT+ affirmation are contradictory because LGBT+ rights are a global Northern phenomenon that is imperialistically imposed on the global South. I argue that a similar sentiment is seen in discussions around gay rights on Aruba as well. A mild example is the frequent reminder that Aruba is autonomous in the decisions surrounding S-SM - even though the push for marriage equality appears to clearly have been started by islanders themselves. (De la Fuente, 2009) I expect that this decolonial homophobia will be another one of Aruba's building blocks of the resistance.

Economy

Although it is less obvious, economic conditions are important predictors of homonegativity. As mentioned before, those that earn less and have enjoyed a lower education, tend to be more prejudiced. It is also clear that attitudes in less wealthy countries tend to skew towards intolerance of out-groups. It follows that within-country variations in wealth also matter. This is also the conclusion of Andersen (2008), who revealed that high income inequality was actually related to homonegativity regardless of social class. The mechanism would be that this inequality undermines social trust, which then produces social intolerance. However, it was clear that in countries with higher economic inequality, the higher earners were still the most 'tolerant' group. Aruba, though it has a relatively high GDP, Aruba has a very high level of economic inequality. (Worldeconomics; CBS, 2019; GlobalData, 2022) Taking this into account, it is likely that, following the literature, Arubans' lower income and high inequality may play a role in their resistance towards minority rights.

Methods

The review of the literature has brought specific questions to be answered in the rest of my research, such as:

- Does religion on the island affect voting choices and opinions of citizens and politicians with regards to same-sex marriage and/or LGBT individuals? In what way and to what extent? [Nationalism & Religion]
- To what extent can machismo/ traditional conceptualisations be said to be influential in homonegative sentiment on the island and/or in the discussion surrounding same-sex marriage? [Masculinity]
- To what extent do Arubans feel that same-sex marriage is forced upon them by the Netherlands? And do they feel negatively about this? [Post-coloniality]

I will be conducting interviews with key stakeholders like NGO's and churches, as well as interviewing LGBT citizens for their experiences living on the island. This should further refine my research. Then I will set foot on what has been called the 'Aruban marketplace'; Facebook. I will analyse discussions that are relevant to the topic to see whether sentiment in the population follows the directions I have predicted based on my interviews and literature review and to answer my questions. I will be getting the help of an Aruban student to lift the language barrier.

Preliminary Results

This section of my paper will cover the data I have gathered so far from interviews with key players in the same-sex marriage discussion on Aruba, namely the church, political party representatives, and those organisations and individuals taking initiative. This is combined with interviews with LGBT Arubans in multiple age groups. It must be mentioned that these were primarily with Arubans who were positive about same-sex marriage, were not (very) religious, and/or were LGBT themselves.

I will start with a characterisation of the climate on the island. Then I will discuss how my findings relate to the potential building blocks I established in the literature review.

The Arubans I have spoken to have painted, fairly unanimously, a picture of an island that is very conservative or even 'backwards', with a tight and judgmental religious community. LGBT people do not feel welcome on the island or within the culture; they feel that they are not considered a 'real Aruban' or even a real man or woman. The environment feels hostile, at home, at school and within the church. People face bullying at school and the workplace and have, anecdotally, even been disinherited by or lost contact with family. Organisations and individuals report being threatened online and even facing violence in practice. The younger generation reports less problems than older generations have (had) with their peers. Still, many LGBT Arubans choose to study, work and live abroad for these reasons.

For my discussion on building blocks, I want to start with a factor I did not consider when going into this research but that has prominently come forward in discussions; ethnicity. Aruba is a diverse island, with a very high rate of immigration; almost 40% of Arubans are 'foreign-born'. (CBS, 2023). This results in quite a high percentage of recent South American immigrants. Multiple interviewees have indicated that the culture among these immigrants differs from that of 'Arubans'. Though it is difficult in practise to define 'Arubans' precisely because of these immigration and emigration rates, I will go by the comments of the interviewees. How the Latino population supposedly differs from the Arubans will be indicated per section I discuss.

The 'block' that has come forward the most in previous research as well as in conversations is religion. All interviewees considered religion to be the most important factor. As stated before, the churches are explicitly opposed to same-sex marriage, repeatedly taking action against progress on this front. They are not entirely united in this; the Catholic churches, which have the largest number of followers on the island, are markedly less radical in their approach and thinking than the other Christian churches. These other churches are largely Evangelical, and have a different ethnic make-up, being frequented by the Latin population. Actions like the signature collection tend to be initiated by these minority churches, with Catholics only joining in the very latest stages. Respondents say that these 'Christian' churches, as well as their Latin American constituents, are clearly more homonegative. Meanwhile, the Catholic church indicates to not be so vehemently against the concept of same-sex marriage per se; merely wishing it to not be called 'marriage'. This more relaxed attitude is confirmed by other interviewees, though they all agree that the Catholic church, too, has majorly contributed to homonegativity on the island throughout their lives.

Another complicating factor mentioned is church attendance. Though it is true that the large majority of Arubans subscribe to a religion, over the past 20 years, church attendance has dropped dramatically, along with a decline in the importance of the church in daily life. Respondents agree that younger generations give a much lower significance to the church. This calls into question the validity of the argument that the high proportion of religious people on the island should legitimate resistance against same-sex marriage; it seems that it is an ethnic as well as a generational minority that is the most, or in the words of some, 'actually' religious.

The next block is the presence of a machismo culture on the island. People in all age groups disagreed on the prevalence of this type of gender role. Though some named it as a factor even without me mentioning gender roles, someone else thought perhaps only 15% of men proscribe to the macho ideals. Generally, people will say that highly masculine and strictly heterosexual gender norms are dominant on the island for men, which goes hand-in-hand with not only strong homonegativity but also with misogyny and high levels of domestic violence. They have indicated a shift towards more lenience on following these gender roles in the last decade, providing some breathing space to LGBT residents. Though at the same time, some feel that they cannot be gay and be seen as a 'real' man or woman. More gender-nonconforming LGBT individuals report having more trouble in their daily lives with homonegativity, mostly through being immediately recognised as being gay. No difference between Arubans and recent Latin immigrants was reported.

To investigate the presence of some form of religious nationalism, I asked interviewees about linkages between the church and the state, with regards to same-sex marriage legislation as well as for past decisions. The church indicated to have been invited to judge the proceedings surrounding the bill and to give advice, and that many individual politicians had come to them as well. However, this was not a common occurrence with other government decisions, making this hard to judge. On the one hand, this shows that politicians do view same-sex marriage to be a religious issue, and this also indicates direct influence from the church on decision-making. On the other, it implies that religious leaders do not normally hold this much sway over Aruban politics. Interviewees believed that the church had great direct influence over politics, either through the politicians being religious themselves and listening to church leaders, or though the fear of losing religious voters. Politicians themselves also indicated that maintenance of voter base was an important reason not to get into the subject. In any case, it seems that a majority of politicians believes religion has a place in politics.

Interestingly, no-one suggested any ill feeling towards a supposed Western influence on the same-sex marriage process, or believed that Arubans viewed homosexuality as something Western, and thus negative. Many actually expressed varying levels of disappointment in the relative lack of interference on this front by the Netherlands; though this would not be appreciated by many Arubans, it is believed that it would have helped the cause. The Netherlands is seen as not protective enough of the citizens within its kingdom. This might be because of the sample of people I have talked to, the majority of which was LGBT and highly educated – in the Netherlands.

Finally, it was also clear through my conversations that people who earned less and were less highly educated – such as students taking MAVO rather than HAVO, or those that had stayed on Aruba instead of attending university in the Netherlands/ the USA – were perceived as clearly being more homonegative and 'backwards' by those I spoke to. This group overlaps largely with recent Latin immigrants but also contains many Arubans.

Concluding remarks

So far, it is not possible to draw any hard conclusions; though those interviewed are broadly in agreement, I have not found one single point everyone agreed on, even like-minded people often completely contradicting one another. This speaks to how much of a personal and emotional dimension this touches upon, as one's personal position in society largely determines how they see it. In any case, it is clear that though there are certain blocks in the way of the acceptance of same-sex marriage, everyone - even those 'against' - agreed that Aruban society was moving in that direction regardless. Many are confident the majority of Arubans welcome this change. A hopeful note to end on.

References

- Adamczyk, A., & Pitt, C. (2009). Shaping attitudes about homosexuality: The role of religion and cultural context. *Social Science Research*, 38(2), 338-351.
- Andersen, R., & Fetner, T. (2008). Economic inequality and intolerance: Attitudes toward homosexuality in 35 democracies. *American Journal of Political Science*, 52(4), 942-958.
- Aruba en Curaçao in cassatie over 'huwelijksapartheid.' (2023, November 22). *Gaykrant*. Retrieved from https://www.gaykrant.nl/2023/11/22/aruba-en-curacao-in-cassatie-over-huwelijksapartheid/.
- Aruba moet homohuwelijk erkennen. (2007, April 13). Het Parool.
- Arubaanse regering wil geen homohuwelijk. (2013, June 13). Caribisch Netwerk. Retrieved from https://caribischnetwerk.ntr.nl/2013/06/13/arubaanse-regering-wil-geen-homohuwelijk/.
- Antillen blijven fel tegen homohuwelijk. (2008, July 26). Het Parool.
- Brown, M. J., & Henriquez, E. (2008). Socio-demographic predictors of attitudes towards gays and lesbians. *Individual Differences Research, 6*(3).
- Central Bureau of Statistics Aruba. (2019, March). *Income and Expenditure Survey 2016: Na unda mi placa ta bay.*
- Central Bureau of Statistics Aruba. (2023, March 27). *Central Bureau of Statistics.* Immigration to Aruba in the last 50 years. https://cbs.aw/wp/index.php/2023/03/27/immigration-to-aruba-in-the-last-50-years/
- Curacao in cassatie tegen homohuwelijk. (2022, December 13). Nu.cw. Retrieved from https://nu.cw/2022/12/13/curacao-in-cassatie-tegen-homohuwelijk/?_gl=1*d1j783*_up*MQ..*_ga*NDI0NTM0NDEwLjE3MTE5OTg1NTU.*_ga_QG505SS6KN*MTcxMTk5ODU1NC4xLjAuMTcxMTk5ODY3NS4wLjAuMA..
- Curaçao wil echt geen homohuwelijk en gaat in cassatie tegen verplichting van rechter. (2022, December 14). Ad.nl. Retrieved from https://www.ad.nl/buitenland/curacao-wil-echt-geen-homohuwelijk-en-gaat-in-cassatie-tegen-verplichting-van-rechter~aee12b42/?referrer=https%3A%2F%2Fwww.google.com%2F.
- Day, C. M. (2023). Decolonial Homophobia: Is Decolonisation Incompatible with LGBT+ Affirmation in Christian Ethics?. *Studies in Christian Ethics*, 09539468231215304.
- Drayer, D. (2022, November 10). Ik mag van curacao alleen met een man trouwen maar ben verliefd op een vrouw. *NOS*. Retrieved from https://nos.nl/artikel/2497392-ik-mag-van-curacao-alleen-met-een-man-trouwen-maar-ben-verliefd-op-een-vrouw.
- *GDP per capita* (current US$) - Aruba. World Bank. (n.d.). https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=AW. Accessed 3-4-2024
- Geregistreerd partnerschap en homohuwelijk naar arubaans parlement. (2015, September 6). *Caribisch Netwerk*. Retrieved from https://caribischnetwerk.ntr.nl/2015/09/06/geregistreerd-partnerschap-en-homohuwelijk-naar-arubaans-parlement/.
- *Gini coefficent.* World Economics. (n.d.). https://www.worldeconomics.com/Indicator-Data/Inequality/Gini-Coefficient.aspx#:~:text=Gini%20Coefficent%20INDEX%20%280-100%29%3A%20100%20%3D%20HIGHER%20LEVELS,high%20inequality%20levels%20and%20100%20represents%20perfect%20equality.
- Hendriksen, K. (2020, September 25). Initiatiefwet homohuwelijk lijkt van de baan: 'onvoldoende draagvlak.' *Caribisch Netwerk*. Retrieved from https://caribischnetwerk.ntr.nl/2020/09/25/initiatiefwet-homohuwelijk-lijkt-van-de-baan-onvoldoende-draagvlak/.
- Henriquez, S. (2021, March 3). Geregistreerd partnerschap geeft arubaanse homostellen nu meer rechten dan met huwelijk. *Caribisch Netwerk*. Retrieved

from https://caribischnetwerk.ntr.nl/2021/03/03/geregistreerd-partnerschap-geeft-arubaanse-homostellen-nu-meer-rechten-dan-het-huwelijk/.

- Hoge raad kijkt naar zaak rondom toestaan homohuwelijk. (2023, November 1). Nu.cw. Retrieved from https://nu.cw/2023/11/01/hoge-raad-kijkt-naar-zaak-rondom-toestaan-homohuwlijk/?_gl=1*d1j783*_up*MQ..*_ga*NDI0NTM0NDEwLjE3MTE5OTg1NTU.*_ga_QG505SS6KN*MTcxMTk5ODU1NC4xLjAuMTcxMTk5ODY3NS4wLjAuMA..
- Inglehart, R., & Baker, W. E. (2000). Modernization, cultural change, and the persistence of traditional values. *American sociological review, 65*(1), 19-51.
- Jäckle, S., & Wenzelburger, G. (2015). Religion, religiosity, and the attitudes toward homosexuality—A multilevel analysis of 79 countries. *Journal of homosexuality, 62*(2), 207-241.
- De la Fuente, c. (2009, September 7). *Het homohuwelijk in De West* (The revival). Mr. Online. https://www.mr-online.nl/het-homohuwelijk-in-de-west-the-revival/
- Juergensmeyer, M. (1996). The worldwide rise of religious nationalism. *Journal of International Affairs*, 1-20.
- Leach, E., & Gore, J. (2022). Culture, religion, and homonegativity: A multi-level analysis. *Mental Health, Religion & Culture, 25*(1), 85-98.
- LGBT-gemeenschap eist excuses van pastoor. (2016, July 9). *Caribisch Netwerk*. Retrieved from https://caribischnetwerk.ntr.nl/2016/07/09/lgbt-gemeenschap-eist-excuses-van-pastoor/.
- Meaney, G. J., & Rye, B. J. (2010). Gendered egos: Attitude functions and gender as predictors of homonegativity. *Journal of Homosexuality, 57*(10), 1274-1302.
- *Median household income in the Netherlands (2010 - 2021, Purchasing Power Parity in current international dollars).* GlobalData. (2022, July). https://www.globaldata.com/data-insights/macroeconomic/median-household-income-in-the-netherlands/
- Mirjam. (2005, August 28). *Ontwikkelingen rondom homohuwelijk op de Nederlandse Antille.* Buitenlandsepartner.nl. https://www.buitenlandsepartner.nl/showthread.php?5675-Ontwikkelingen-rondom-homohuwelijk-op-de-Nederlandse-Antille
- Namens meerderheid bevolkingen. (2024, March 14). *Antillaans Dagblad*. Retrieved from https://antilliaansdagblad.com/nieuws-menu/29174-namens-meerderheid-bevolkingen.
- Opinion: carta habri di iglesianan: legalisacion matrimonio homosexual curaçao y aruba. (2024, March 13). *NotiaCla*. Retrieved from https://www.noticiacla.com/news/30700.
- Parlementariër vraagt kerkleiders om zich uit te spreken tegen gaypride. (2013b, September 26). *Caribisch Netwerk*. Retrieved from https://caribischnetwerk.ntr.nl/2013/09/26/parlementarier-vraagt-kerkleiders-om-zich-uit-te-spreken-tegen-gaypride/.
- Pena-Talamantes, A. E. (2013). Defining Machismo. *No Es Siempre Lo Mismo: Latino.*
- *Practiced religions in Aruba - churches, Temples & Holy Places.* Practiced religions in Aruba - Churches, Temples & Holy Places | Aruba.com. (n.d.). https://www.aruba.com/us/our-island/history-and-culture/religion#:~:text=More%20than%2075%25%20of%20Aruba's,celebrated%20with%20fervor%20and%20devotion.
- RAIZ stelt ultimatum voor behandeling wet homohuwelijk op aruba. (2024, March 2). *Aruba.Nu*. Retrieved from https://aruba.nu/2024/03/raiz-stelt-ultimatum-voor-behandeling-wet-homohuwelijk-op-aruba/.
- Reese, G., Steffens, M. C., & Jonas, K. J. (2014). Religious affiliation and attitudes towards gay men: On the mediating role of masculinity threat. *Journal of Community & Applied Social Psychology, 24*(4), 340-355.
- Rijcken, P. (2024, March 5). *Cassatie - over het*

homohuwelijk in Aruba en curaçao - rijckwijdte - de podcast van pels rijcken. Buzzsprout. https://www.buzzsprout.com/1905138/14630768

- Slaatten, H., & Gabrys, L. (2014). Gay-related name-calling as a response to the violation of gender norms. *The Journal of Men's Studies, 22*(1), 28-33.
- Smith, A. D. (1992). National identity and the idea of European unity. *International affairs, 68*(1), 55-76.
- Spier, B. (2019, January 28). Al 10 jaar geen nieuw burgerlijk wetboek aruba mede vanwege partnerschap gelijke sexe. *Caribisch Netwerk*. Retrieved from https://caribischnetwerk.ntr.nl/2019/01/28/al-10-jaar-geen-nieuw-burgerlijk-wetboek-aruba-vanwege-partnerschap-gelijke-sexe/.
- Sremac, S., & Ganzevoort, R. R. (2015). *Religious and sexual nationalisms in Central and Eastern Europe: Gods, gays and governments* (Vol. 26). Brill.
- Stamper, M. (2023, November 9). Is aruba klaar voor de roze revolutie? *Caribisch Netwerk*. Retrieved from https://caribischnetwerk.ntr.nl/2023/11/09/is-aruba-klaar-voor-de-roze-revolutie/.
- Štulhofer, A., & Rimac, I. (2009). Determinants of homonegativity in Europe. *Journal of sex research, 46*(1), 24-32.
- Tweede kamer eist erkennen homohuwelijk op curaçao, aruba en sint maarten. (2023, February 17). *RTLnieuws*. Retrieved from https://www.rtlnieuws.nl/nieuws/nederland/artikel/5366213/antillen-homohuwelijk-hoge-raad-tweede-kamer-van-huffelen.
- *Tweede Kamer pleit voor homohuwelijk in Cariben*. Knipselkrant . (2015, June 15). https://knipselkrant-curacao.com/amigoe-tweede-kamer-pleit-voor-homohuwelijk-in-cariben/#:~:text=DEN%20HAAG%20%E2%80%94%20De%20Tweede%20Kamer,landen%20op%20aan%20te%20dringen.
- Van den Akker, H., Van der Ploeg, R., & Scheepers, P. (2013). Disapproval of homosexuality: Comparative research on individual and national determinants of disapproval of homosexuality in 20 European countries. *International Journal of Public Opinion Research, 25*(1), 64-86.

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I learned so many new things about my island.

Reflecting on the time spent being part of this project isn't easy to do. This project was interesting and helped me understand a lot about the island I call home, issues I haven't even been aware of, and places I haven't been/explored even though the island isn't visible on the global map because of its small size is an interesting way of finding out how little you know about the place that someone might call home. The program is also a fascinating experience into compromises, learning to work with someone with a different perspective than you, and working together to create something amazing. It's also something that inspires hope for me when it comes to looking at the future, as my outlook on the future before the program was honestly a pessimistic one. Hope is something that one should have for the future which is a great lesson to leave the program with and one I will do my best not to forget.

I would like to express my heartfelt gratitude to everyone in the UCU program I've met and worked with as I learned so many new things about my island and their own countries in such a short time.

Food drying and food security: the case of the Aruban mango

Siguerd Obispo

Introduction

The COVID pandemic negatively affected Aruba's economy due to the island's reliance on tourism (World Bank 2020), resulting in a significant rise in awareness of Aruba's fragile food security. However, The pandemic shed light on Aruba's agriculture industry, with initiatives being made to help Aruban food entrepreneurs through microfinancing initiatives that receive government backing (Rendell de Kort et al 2024). While the Aruban food industry is moving forward it still has its' limitations. One of these limitations lies with a fruit that is cultivated here on the island: the Aruban mango. The Aruban mango grows year-round and is cultivated all around the island. The current issue with Aruban mangoes is that a tree will produce a large amount of ripe mangoes in a short amount of time. This leads to a significant portion of the harvest perishing and not being fully utilized for consumption. A potential solution to this problem for fruits and vegetables is drying them. This will not only extend the shelf life of the mangoes but will also minimize the food waste produced. However, the drying characteristics of the Aruban mango are not well documented. Without this data or knowledge on food drying practices, it would be difficult to make drying of the Aruban mangoes more widespread as we don't have information on the optimal drying conditions. This research paper aims to take the first step in solving this problem by testing the drying characteristics of Aruban mangoes and giving the results to give baseline comparative data for mango drying, which can be used to for testing drying effectiveness of different drying techniques and make fruit and mango drying more widespread on the island of Aruba.

Literature review

When looking at the drying characteristics of mangoes, it is important to look at past experiments on similar produce and how they have been able to gather this data. McMinn and Magee(2003) experimentally describe the adsorption and desorption isotherms for specific types of potatoes, using mathematical models to interpret the data derived from their experiments. They use a standard gravimetric static method to determine the moisture adsorption and desorption isotherms at various temperatures and various humidities. Their methodology emphasizes precision in the gravimetric static approach. The setup involves placing triplicate samples of potatoes in desiccators, and experimental food dryers, in a total of 7 different saturated salt solutions to create constant humidity environments. The reliability of this methodology is further enhanced through their approach to equilibrium content where the samples were kept for 3 weeks until a constant weight was reached (equilibrium). The potatoes' bone dry mass was determined by keeping the samples in the oven at 105-110 C for 8 hours. The significant finding of this study is the type 2 characteristics of the adsorption and desorption isotherms and their' temperature dependence for the total adsorption and desorption capacity. This means that the adsorption and desorption capacity is decreased with increasing temperature. The Guggenheim–Anderson–de Boer (GAB) and Halsey models were found to be able to describe the adsorption and desorption characteristics of these potatoes adequately. It means this model could be key in predicting the adsorption and desorption characteristics of the Aruban mangoes as well. This research and its methodology serve as the basis for getting the desorption and adsorption characteristics of our mango as explained in the following section of this paper.

Methodology

The adsorption and desorption characteristics of the Aruban mango are determined by the standard gravimetric technique with the mango being sliced into thin discs of 1 cm and then placed on simple Petri dishes with 7 saturated salt solutions to properly simulate a constant humidity environment as well as an environment with a different temperatures to put in temperature-controlled cabinets. Preferably this is done at temperatures ranging from 30-60 C as food drying for consumption purposes is usually done at those temperatures(McMinn and Magee 2003). The samples are dried in this manner until they reach a constant equilibrium weight, then using the oven drying method, where we put the samples in the ovens at 105-110C for 8 hours we can measure the bone dry weight of the mangoes. We then start using models to describe the experimental adsorption and desorption data. For this research, there are 2 models which come to mind for modeling the adsorption and desorption characteristics The 2 models used are as follows:

GAB (Van den Berg & Bruin, 1981)

$$X = X_0 C K a_w / [(1 - K a_w) \times (1 - C K a_w + C K a_w)]$$

Halsey (Halsey,1948)

$$X = [\frac{-A}{ln\,(a_w)}]^{1/B}$$

Figure 1: Formulas for the GAB and Halsey Models

MRE%
The models' effectiveness are compared using the MRE % by Chen & Morey:

$$MRE = \frac{100}{N} \sum \left| \frac{M_e - M_p}{M_e} \right|$$

Figure 2: MRE% Formula

Heat Involved in Water Absorption
When water is absorbed by something solid (like when drying mangoes), we measure how much energy this process needs. This is the isosteric heat of sorption which will help us understand how tightly the water is held by the solid. We calculate this energy by comparing it to the energy needed to turn water into steam (vaporization). This is calculated from the experimental data using the Clausius–Clapeyron equation (Figure 3)

$$\left[\frac{d(ln\, a_w)}{d\,(\frac{1}{T})} \right]_X = \frac{\Delta h_d}{R}$$

And

$$\Delta h_d = \Delta H_d - \Delta H_{vap}$$

Figure 3: Clausius Clapeyron application

This value measures how much energy is used when water molecules stick to a solid at a specific level of moisture (X). By drawing a graph that shows the relationship between water activity (aw) and the inverse of temperature (1/T) for a certain moisture level, we can figure out the energy needed for the drying process (Dhd) by looking at the slope of the line (Dhd=R). This method assumes that the energy change (Dh) doesn't vary with temperature and requires us to look at how moisture is absorbed or released at more than two different temperatures.

Enthalpy-entropy compensation theory

The enthalpy-entropy compensation theory explores how the heat required for water absorption (isosteric heat, DHd) and the disorder (differential entropy, DSd) during absorption relate to each other. This relationship can be represented mathematically as:

$$(-ln\ a_w)_X = \frac{\Delta H_d}{RT} - \Delta S_d/R$$

By graphing ln(aw) against 1/T for a specific moisture level (X), we can calculate DHd from the graph's slope and DSd from where the line crosses the y-axis. This method lets us see how DHd and DSd change with different moisture levels.

According to the theory, there's a direct line relationship between DHd and DSd:

$$\Delta H_d = T_\beta \Delta S_d + \alpha$$

We use linear regression to find the isokinetic temperature (Tb) and a constant (a). To test this theory, we compare Tb to the harmonic mean temperature (Thm); the theory holds true if Tb does not equal Thm.

This theory also helps us understand how temperature influences water absorption. By modifying the equation to:

$$T_{hm} = \frac{n}{\sum\ (\frac{1}{T})}$$

we ignore parameter a because it doesn't significantly impact the enthalpy change.

To further examine temperature's effects on absorption, we adjust the equation to:

$$(a_w)\ = \frac{\Delta H_d}{R(\frac{1}{T} - 1/T_\beta)}$$

where WT is a temperature adjustment factor in the isotherm equation, calculated as:

$$\Psi_T ln\ (a_w) = K\ \Phi(X)$$

and U(X) is a formula that depends on moisture, reflecting the link between water activity and moisture content. This adjustment ensures that data at different temperatures align when graphed according to this equation. Following this approach, we find that an exponential function can describe this relationship:

$$\Psi_T ln\ (a_w) = K_1 K_2^m$$

For the overall heat and disorder from water absorption at a constant condition (net integral enthalpy, Dhin), it's calculated similarly to isosteric heat but under a constant pressure. Graphing ln(aw) against 1/T under this pressure lets us find Dhin from the slope. We calculate the spreading pressure (p) and adjust the values for the relationship between a_w and X at very low aw values (aw = 0.05 used as a practical lower limit). The overall disorder associated with water absorption (integral entropy, DSin), reflecting the system's disorder at different temperatures and pressures, is derived from:

$$\Delta S_{in} = -\left(\frac{\Delta h_{in}}{T}\right) - R\ ln\ (a_w^*)$$

Relevance

This research serves as the first step to understanding the potential of drying local mangoes on a more scientific level, as there is currently no data available on the thermodynamic properties of the Aruban mango, this research can also pave the way for a more developed understanding of of the thermodynamic properties of local foodstuffs. In the case of mangoes, it will aid the local market by starting to understand how to dry the mangoes in the most efficient way possible. This focus on efficiency will lead to less spoilage of the mangoes and contribute to the strengthening of the local food production market. This research will also provide a basis for further comparative studies, particularly in evaluating the efficiency of drying methods as there are different types of dryers, including sustainable ones such as a solar-powered food dryer (Hermans & Vandommele, 2021) and currently being worked on by Kailas Malwade This paper describes using the oven drying method to compare the drying efficiency of their food system to its' bone-dry mass. The research currently conducted in Aruba will allow us to do the same for the Aruban mango, and by extension for other produce, by providing a baseline for comparison by getting a range of bone-dry mass values for these local products.

Future outlook

Potential challenges: Currently, there is difficulty with gathering the equipment necessary for the isothermic analysis of mangoes, so it is important to maximize productivity when the equipment arrives, as well as being able to get Aruban mangoes of a consistent quality will be a notable challenge in this research. Being able to carry over the methodology mentioned earlier will also depend on the equipment and the ability to record data, as data reliability will be a top priority.

Another important factor to consider is the climate the island faces as the experiments will be conducted during the summertime when the climate will be a bit hotter than usual.

Overall, this research is moving along and data collection and experimentation will start sometime soon and an update will be provided when that time arrives.

References

- de Kort, R., Obispo, S., Carmona Baez, A., Echteld, L., & Mijts, E. (in press/2024). Strengthening economic resilience in small island states: A situational analysis of food entrepreneurship, with a focus on the Cucumis Anguria cucumber in Aruba.
- McMinn, W.A.M., & Magee, T.R.A. (2003). Thermodynamic properties of moisture sorption of potato. Food Process Engineering Research Group, School of Chemical Engineering, Queens University Belfast.
- Wolf, M., Speiss, W. E. L., & Jung, G. (1985). Standardization of isotherm measurements. In D. Simatos, & J. L. Multon (Eds.), Properties of water in foods (p. 661). Dordrecht: Martinus Nijhoff.
- World Bank. (2020). Building Aruba's food security during the COVID-19 pandemic and beyond. Global Facility for Disaster Reduction and Recovery. https://www.gfdrr.org/en/publication/building-arubas-food-security-during-covid-19-pandemic-and-beyond

Gemma Negrini, Utrecht University

I loved the openness of the people.

There aren't enough words to explain adequately on paper what this experience meant to me, but I will still attempt to share it with you. I embarked on this journey mainly as a test to determine whether the subject of my academic studies, as applied in academic research, would truly interest me. I was so focused on the academic opportunity that I had not even realized where I was going. Once I discovered Aruba's location, I began to wonder what it would mean for me to live on an island, a confined space in the middle of open water.

This image of closeness and openness perfectly summarizes the feeling I have for this island. I loved the openness of the people welcoming us as much as I was curious about how closed-minded tourists can be about the nature and local situations on the island. I loved the intimacy of the university, where for the first time, I was not a number but finally a person considered for their ideas and able to articulate my opinions. At the same time, I was surprised by the connection that our course has with the rest of the world, with professors and experts from various backgrounds.

I loved how the dynamics of this island bring complete strangers to become your closest confidants, while also knowing that you might meet them again, who knows where, in the rest of the world. The best idea I started sharing since I have been introduced this island is that understanding the concept of being limited to a closed, bound space, can be a model for global dynamics and can give young students the tools to understand the world they are so curious about, better.

Society government interaction: a case study on the community perspective on the role of Aruba government.

Gemma Negrini

Introduction

This paper examines how farming communities interact with government structures in the small island nations of Aruba, highlighting the difficulties faced by both groups and emphasizing the importance of examining the complex relationships between society and government. This investigation is crucial for understanding how the current dynamic between parts is in perspective of the principles of good governance (De Vries, 2013). The aim of understanding this relationship is to give the government institutions of Aruba a tool to ease the process of implementing solutions for the primary sector. The outcomes of this investigation will be an addition to the work conducted for the Consultancy project focused on business and energy for the implementation of rainwater harvesting systems (RWH) for the Aruban Department of Agriculture, Husbandry and Fisheries, Santa Rosa (*Final report guidelines,* Appendix I). The analysis aims to identify potential cases for transformative change for a more cohesive and comprehensive relationship (Canales, 2015).

The relevance of this topic is underscored by the government's interest in the diversification of economic development, which is currently fully focused on the tourism sector, as highlighted by Hofman et al. (2021). Currently on the island, the primary sector's contributes minimally to the production of the food consumed on the island (Boyer et al., 2020). The food system predominantly relies on imported goods, which raises concerns about food security, as evidenced by the World Bank's publication of the Aruba food security report in 2020.

The necessity of cooperation among diverse stakeholders, including government bodies, civil society, and private actors, for the adoption of sustainable development practices, is articulated by Lambin and Thorlakson (2018). The influence of these collaborative actions on the efficacy of sustainability standards necessitates further investigation, particularly from the perspective of Small Island Developing States.

This paper aims to present an analysis of the reasons underlying the constraints that impede the development of the primary sector in Aruba. This analysis is conducted through a community-based research approach, which integrates the insights of the local community into broader theoretical perspectives to explore the barriers and constraints of Aruba's farmers. The research seeks to elucidate the perspectives of local farmers on their expectations of government involvement in the development of the primary sector. The paper aims to contribute to the literature on this subject for SIDS primary sector development through governmental support.

However, the execution of the research encountered challenges stemming from the lack of data on the status of agriculture systems on the island and the government's agenda for sectoral development. Consequently, the research will concentrate on gathering the perspectives of the farming community regarding the government's role in primary sector development. The discussion will provide a comprehensive answer to the question: "What is the community perspective on the government as a stakeholder for the development of Aruba's primary sector?"

Literature review

The theoretical approach to a lack of data in an unexplored field requires some preparation that deserves a separate section that introduces the methodological approaches chosen to conduct the research that is presented in this paper. the section will first focus on methodology approaches like grounded theory and community-based research, then the sustainability relevance of this topic through SDGs, then food security and at last local governance.

In this research, the approach used is Grounded Theory. As there currently is no academic analysis available in the literature about governance for the primary sector on the island of Aruba, all the data and knowledge produced for the topic will have to be theorized from zero with the help of comparisons with similar situations or nearby territories. Hence, the Grounded Theory approach is followed, as it allows for the systematic development of theory in social settings and it depends upon inductive approaches, which is appropriate for a study mainly aimed at theory development. Moreover, this theory is appropriate for this style of research as, according to Burns and Grove (2009), qualitative research is a systematic and subjective approach to highlight and explain daily life experiences and to further give them proper meaning (Khan, 2014).

The community-based research (CBR) approach that was adopted for this project allows for a focus on daily life experiences and the relationship between the farmers and governmental institutions. Community-based research is a method that emphasizes the active participation of the interested community with the purpose of better collaboration between research partners to identify needs, problems, and assets in special communities (Salimi et al., 2012). Furthermore, the CBR approach does not just help the researcher in the construction of the database, but more importantly, it should grant transparency in the intentions of the researcher towards the community. The approach helps maintain respect and a more inclusive perspective in knowledge formation (Strand, 2003).

In the preliminary phase of this research, it was essential to elaborate and read more about Small Island Developing States. This definition was first used in the Rio de Janeiro conference in 1992, and most recently restated in the Paris Agreement in 2014 relating to their sustainability challenges (United Nations, n.d.). Differently from other countries, small island states face different challenges that have to be taken in consideration when adopting action for SDGs both natural and socio-economic (*Chapter 15: Small Islands,* n.d.). Aruba installed their SDG Commission in 2018 mandated by the Government of Aruba (Kingdom of the Netherlands, 2021). There has been a noticeable improvement across most of the goals and some steadiness for others including 'no hunger', highering the relevance of investigating and producing more knowledge for granting food security.

The previous digression on SDGs has highlighted the relevance of the strengthening of the primary sector on this island is food security. As presented by the report from the Food and Agriculture Organization (FAO) of the United Nations (2014), the challenge is to implement effective and efficient problem-solving policies in ways that are regarded as legitimate by the stakeholders who are involved, enabled, or otherwise directly affected by the decisions and actions undertaken by any governance structure or regime, as well as building and strengthening the capacities of national institutions according to priorities. Specifically on the island of Aruba, there has been a report from the World Bank organization (Boyer et al., 2020) regarding food security on SIDS after the Covid period, highlighting the critical situation regarding the almost full dependence on external parties for food as well as minimal focus on local food production. According to the latest updates from the Minister of transport, Integrity, Nature and Senior Affairs Ursell Arends, the local food production is now 3% of the food consumption on the island, showing improvement (personal communication, April 8, 2024).

Last in this section, this paper also adopts a governmental perspective, as the theme of local governance has reached substantial attention in sustainability discourses (Wang et al., 2014). The little availability of material regarding the study of governance on the island of Aruba has not found a similar discussion of societal-governance interaction, hence the material has included the use of material from the Caribbean island. Good Governance includes all the practices and dynamics that a government acts upon taking into consideration their actors (De Vries, 2013). Specifically local governance takes into consideration the complexity of society dynamics. According to Canales's (2015) literature review, there has been an increasing involvement in the gradual discovery and acceptance of the diversity of actors and institutions involved in the work of local governments and local politics. The paper concludes with how local governance benefits from understanding the importance of a participatory community for better communication between the parties (Canales, 2015). The role of local governance goes further, without excluding the importance of governance as citizen participation, into a deeper understanding of the dynamics of the interactions between all the societal actors.

A final and fundamental global topic that highlights the relevance of the strengthening of the primary sector on this island is food security. As presented by the report from the Food and Agriculture Organization (FAO) of the United Nations (2014), the challenge is to implement effective and efficient problem-solving policies in ways that are regarded as legitimate by the stakeholders who are involved, enabled, or otherwise directly affected by the decisions and actions undertaken by any governance structure or regime, as well as building and strengthening the capacities of national institutions according to priorities. Specifically on the island of Aruba, there has been a report from the World Bank organization (Boyer et al., 2020) regarding food security on SIDS after the Covid period, highlighting the critical situation regarding the almost full dependence on external parties for food as well as minimal focus on local food production. According to the latest updates from the Minister for Nature… the local food production is now 3% of the food consumption on the island, showing improvement (personal communication, April 8, 2024).

Methodology

The data used for this paper is a component of the comprehensive research project conducted for a larger Consultancy report on the Implementation of rainwater harvesting systems. The data collection spanned ten weeks and encompassed various research approaches: systematic literature review, content analysis of previous data gathered by the client, an anonymous survey to gather more specific data on RWH feasibility and awareness on the island, and semi-structured interviews to gather in-depth insights on how the local community perceives the implementation of such systems in their country.

The interview method was selected as the primary data source for the results section of this paper. These interviews were designed to address the sub-research question, "What is the perspective of stakeholders regarding the implementation and adoption of RWH systems, and how does this influence current development?" They were subsequently adapted to elaborate on the scope of this research.

type of personal communication	Contact	Date
introduction	farmer	1/3/2024
introduction	household	1/3/2024
introduction	household	1/3/2024
contacts	Pop up Farmers Market Santa Rosa	2/3/2024
introduction	farmer	4/3/2024
project presentation	Present at & attend board meeting United Farmers	7/3/2024
introduction	farmer	11/3/2024
introduction	farmer	11/3/2024
introduction	vocational school	13/3/2024
introduction	farmer	13/3/2024
Interview 1	household	13/3/2024
Interview 2	household	15/3/2024
Interview 3	farmer	15/3/2024
Interview 4	small-business	21/3/2024
Interview 5	household	21/3/2024
Interview 6	farmer	22/3/2024
Interview 7	household	25/3/2024
Interview 8	small-businesses	25/3/2024
Interview 9	farmer	26/3/2024
Interview 10	farmer	26/3/2024

Table 1- Summary of personal communication and visits done by the local group of the Consultancy project

The interview selection process commenced with an organized number of visits to stakeholders in collaboration with Santa Rosa to facilitate initial familiarization with the community (Table 1). the interviews focuses on the selected gorup of stakeholders shared with the consultant client, namely farmers (commercials and traditional), small businesses[1] and households that had a RWH system in place.

Once a network was established, the research group collectively determined which contacts would be pertinent to the sample scope of the research and subsequently approached them for participation. The data was recorded using the microphone functionality of the students' phones, with prior consent obtained from all participants. Prior to the commencement of recording, a formal request for the use of the material within the scope of the research was documented, and consent was obtained from all respondents.

Initially, all interview recordings were transcribed using Word transcriber software. Each transcript was carefully reviewed by a member of the research team to ensure accuracy and completeness. This process facilitated familiarity with the data and allowed researchers to immerse themselves in the content. Following transcription, the data were subjected to coding, a process wherein meaningful segments of text were systematically identified and labeled with descriptive codes. Coding was conducted collaboratively by all team members using NVivo software. Initial coding focused on capturing key concepts, ideas, and recurring themes related to stakeholders' perspectives on RWH implementation and its influence on development.

Once the initial coding was complete, a subset of interviews, representing diverse stakeholder groups, was selected for further analysis. These interviews were independently coded by all team members to ensure intercoder reliability and consistency. The team then convened to compare and reconcile their coding schemes, discussing any discrepancies and reaching a consensus on the final set of codes. With the coded data in hand, thematic analysis was employed to identify overarching themes and patterns (Braun et al., 2006). Themes were derived through a process of iterative review and comparison of coded segments across interviews. Patterns emerged as commonalities and variations within the data were examined, allowing for a deeper understanding of stakeholder perspectives and experiences. The numbers next to the code summarize the number of citations per code. Note that the different layers are not supposed to add up to each other, the classification in a layer depends on the specificity of the citation.

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[1] Aruba classifies businesses with less than 10 full year equivalent employees as small enterprises (DEACI, 2018).

Code layer 1		Code L2		Code L3		Code L4	
Background	8	Personal occupation	8				
		Knowledge	13				
National level	3						
Personal perspective		Limitation on implementation	26	Lack of knowledge	13		
				Lack of regulation	7		
				Lack of economic viability	15		
				Lack of aesthetic	7		
				No interest in water	4		
				Physical problems	6		
		Opinion		Santa Rosa	5		
				Government	12		
				Web	14		
				Community	22	Farmers	3
						Household	7
						Business	7
				Rainwater harvesting system	13	Agroforestry	4
						Rain gutters	4
						Regenbak	2
		Reason for implementation	15	Sustainability	11		
				Production	2		
				Money	5		
Solution		Examples	17				
		Innovation	22				
		Failed solutions	4				
		Positive on present solution	10				

Table 2- Codes of interview and number of citation per code

Table 2 shows codes used to analyze the transcripts of the interviews in NVIVO. The thematic analysis of the interviews gave a layered organization of the local RWH systems and the theme relation with the primary sector/sustainability/nature perspectives. The numbers next to the code summarize the number of citations per code. Note that the different layers are not supposed to add up to each other, the classification in a layer depends on the specificity of the citation with L1 being the least specific to L4 most specific.

The identified themes and patterns were then analyzed within the context of existing theoretical frameworks and literature on society-government interaction, sustainable development, and water management. This allowed for a more nuanced interpretation of the findings and facilitated theoretical triangulation, whereby multiple theoretical perspectives were integrated to enrich the analysis.

The extensive table presented above is a product of the consultancy report. This paper focuses on the codes derived from the opinions collected during the interviews. Specifically, the interviewed subjects articulated distinct opinions regarding the Aruban government, Santa Rosa (the Department for Agriculture, Fishery, and Husbandry), as a government organization, and the WEB company, which produces water and electricity for the island and is owned and regulated by the government. These criteria were subsequently employed to formulate the sampled perspective of the Aruban community in accordance with the theorization principle of grounded theory.

Results

This results section provides an in-depth elaboration on the findings derived from the interviews. The primary objective is to offer a comprehensive overview of each interview, focusing specifically on the perspectives of the interviewees regarding the government, its subdivisions, and the local community.

A total of 10 interviews were conducted, aligning with the expectations outlined in the research plan. Among these interviews, focused on investigating the opinion of the identified stakeholder groups namely farmers, small-business owners and house owners, 4 participants were of the first category, 2 of the second, and 4 of the last. Specifically, among the farmers, two engaged in commercial farming, predominantly producing lettuce for the hotel industry using hydroponic systems. Interestingly, neither of these individuals was born on the island, with one originating from the US and the other from the Netherlands. Both started their businesses on the island around 2017. The third farmer operates on a smaller scale, specializing in more complex products such as vegan wraps and burgers, sourced mainly from fruit trees, and sold primarily to local supermarkets. Originating from Germany, this individual started the business upon moving to the island. The fourth farmer, also from Germany, is no longer active in production but has delegated production mainly to family and friends.

Regarding the household interviews, participants included a consultant engineer for the government, a professor/engineer and agricultural business owner, a wastewater engineer, and a retired teacher. Notably, only one of these participants was born in Aruba and the others originating from overseas, moved on the island at least a decade ago for either their retirement or their job.

The first interview with a small business was conducted with the only rain gutter installation company on the island, while the second business focused on disseminating knowledge about syntropic forest gardens and communal green spaces. Following the transcription and coding process outlined in the methodology section, thematic analysis was employed to categorize the codes. Relevant codes for this paper included opinions, lack of regulation, and aspects of implementation solutions.

The relevant codes for this paper include the opinion (layer

2, table 2) with all the subcodes of the case. The result includes the 'lack of regulation' code (layer 3 table 2) and part of the 'implementation'< 'solution' codes (layers1,2, table 2).

Opinions

The thematic code encompassed all direct opinions highlighted in the interviews. It's noteworthy to consider that the questions asked were part of the consultancy project data gathering, which pertains to stakeholders' perspectives in the context of rainwater harvesting systems. However, none of the interviewees limited their answers to the investigated topic.

The opinion regarding Santa Rosa, a subdivision of the Aruba government, varied from being perceived as lacking in impact to being recognized for its role, primarily tasked with finding solutions for the lack of knowledge regarding the primary sector.

'That can give the farmers a financial, with two or three percent of income of interest. You have to sell. You have to take the risk. You have to accept the risk. (Interview 3, personal communication, March 15, 2024)'

'Also don't think that they should go aggressive on this (rainwater harvesting systems), but I think they should incorporate it in bigger plans and policies' (Interview 1, personal communication, 13 March,2024)

'Think they can start with the, let's say with community houses. We just did one in San Nicholas. It's a big house and the water just goes away. I think the government can start with that.' (Interview 4 , personal communication, 21 March, 2024)

The opinions regarding Santa Rosa fall into the scope of the research as the department is a subdivision of the Aruban government. The perspective on the department goes from being identified as lacking in impact for their associates to having the recognition of their role. But mainly respondents give Santa Rosa the task of finding a solution for a perceived lack of knowledge regarding the primary sector and what is related to it.

'That is one of the poor situations of Santa Rosa. Santa Rosa has no person that can visit the farmers and give them information, because Santa Rosa is a political department' (Interview 3, personal communication, 15 March, 2024)

'I think that should be a role with Santa Rosa that they should be, which they've done up to this point. They have, they do that to a certain extent. Where you can go there and get seeds and different stuff like that.' (Interview 10, personal communication, 26 March, 2024)

The opinion regarding WEB, is related to this research as the company is owned by the government. Interviewees have quite a uniform opinion on WEB: the first one is the idea that water is expensive and the second is that WEB water is dead and not good for the primary sector.

'Because they're technically a government entity, their profits are somewhat regulated, or go back into the government office, right? The only and I do see the potential for abuse and misuse' (Interview 5, personal communication, 21 March, 2024)

'Like the rainwater instead of the WEB water because the WEB water doesn't have any nutrients or minerals. It doesn't have too many nutrients or minerals, you know' (Interview 4, personal communication, 21 March, 2024)

The opinions on community includes all that are not specific on the governmental institutions but more on the values of the farming community, households, and small businesses. Generally, respondents refer to a lack of communication between actors of the same sector and a lack of shared information between government and society. Furthermore, 8 out of 10 interviews have mentioned the United Farmers Association, with critical opinions on how the board has dealt with the farming community.

'Farmers here on the island is like minimum. Because everybody is afraid. That I shot it, and they all stole' (Interview 6, personal communication, March 22, 2024)

Finally, criteria like lack of regulation or solution are used complementary to the direct opinion on the government and community role as the interviewees refer to the governmental organization indirectly mostly to justify what must be done.

Discussion and Conclusion

The study aimed to address the research question: 'What is the community perspective on the government as a stakeholder for the development of Aruba's primary sector?' This discussion will first examine whose perspective we have analyzed and the societal background of the sample. Furthermore, it will evaluate the extent to which our findings answer the research question.

When initially approaching this research, the research group relied on common knowledge definitions inherent to our cultural background, as outlined in the guidelines that are set for the Consultancy Project. Specifically, our positionality western highly educated sustainability students led us to associate a Department of Agriculture, Fishery, and Husbandry with a flourishing and productive primary sector governed by a comprehensive institution tasked with administering the community socioeconomically. However, conducting research in a country with a vastly different background from our academic environment underscored the importance of approaching individuals who could introduce us to the topic while respecting cultural perspectives. Thus, utilizing a community-based approach not only aided in data collection but also broadened our perspective to encompass the entire island mentality.

400 Farmers are associated with Santa Rosa, many of these identify as *cunukeros*. A *'cunukero'* (personal communication, 2024) refers to anyone with a piece of farmland, typically in the most traditional areas of the island, who may not consistently grow crops. Unlike in other locations, dedication and productivity are not always as crucial in this profession. Conversely, the Aruban government's care for the island's primary sector is primarily limited to productivity indexes to justify financial support. Furthermore, the association with the term *'cunukero'* also implies characteristics such as poverty, traditionality, backwardness, and stubbornness. This shared understanding influences how the community frames involvement in the island's economic development through the primary sector. From this perspective, the most significant informational gap was identified between the idealized definitions and expectations of farmers and the way the Aruban government deals with its primary sector. It was interesting to identify the disparity between what the community involved in production identifies in defining their job and how the Department of Agriculture, Fishery, and Husbandry presents its members. The consultancy team was genuinely surprised when the expectations that had constructed the research in the preliminary phases were not met and rephrased the research aim to adapt it to the realistic, even more complex, responsibilities of Santarosa.

In addition to differences in perspective, the research we were tasked with aimed to investigate which rainwater harvesting systems are more feasible for adoption among farmers and other stakeholders on the island. However, the discrepancy between research intent and community feasibility has prompted us to question the viability of the extensive implementation of Rainwater harvesting systems, a general task of the Consultancy project. Government institutions such as Santarosa and other departments, may seek to enhance sector productivity without fully understanding the societal status of farmers; rather than technological advancements, their approach seems more like 'a pat on their shoulders by the end of the day' (Interview 3, personal communication, March 15, 2024).

Moreover, it is intriguing to compare the World Bank report on food security (Building Aruba's Food Security During the COVID-19 Pandemic and Beyond, 2020) goals with the island's agricultural practices. The report's two pillars advocate for commercial-scale food and agriculture and widespread microscale residential producers. However, these implementations require significant economic capital, which, from the community's perspective, may not be available or worth the investment. This is where Canales's (2015) concept of local governance can be applied to community-government practices on the island. Improved communication with and control over the Aruban farming community by the Department of Santa Rosa would facilitate a more sustainable approach to development in the primary sector, especially considering the goals and intentions set by the Aruban Government during the pandemic period (F. Timmen, personal communication, March 22, 2024).

Instead of solely focusing on monetary interests during such a transition, what the farming community has identified as a limitation to development is the lack of value given to production independence and agricultural practices. Incorporating these sustainability values into the community approach could yield better results than solely presenting a monetary investment devoid of inherent worth. To apply this shift it is relevant to convey the community's wishes regarding their 'people.' Due to the historical association with the role of farmers in society, there has been a generational gap in agricultural workers on the island. As evidenced by our interviews, none of the farmers interviewed were originally from the island and none had been practicing agriculture their whole lives. what was deduced from the results might have been different if another sample, maybe more inclusive of Aruba-born farmers. Consequently, there is no traditional way of conducting agriculture, and innovations are often kept private, as there is a fear of theft and profit loss.

Santa Rosa could be a centralized support entity for agricultural development during difficult times and a unified community representing agricultural practices to other institutions. Next to that, many interviewees identified the need for an inclusive farming society or cited external examples, such as the farming community of Curaçao (Placci et al., 2022), as efficient farming communities that support each other. However, there is already the United Farmers Association on the island that has received disharmonious opinions from the interviewees; part of them have identified the association as laborious and functioning, the other part have expressed their critiques on how the board of the association had tied too much to the government not representing the wishes of the community anymore. Something that could be taken into consideration from the department is contributing to creating a safe space for the community to rise and freely present their concerns and advice within the agricultural practices

In conclusion, the perception of the respondents to the interviews and surveys is that to achieve the further development of the primary sector in Aruba, the goals and objectives for the development of the island's primary sector should take into consideration the resources and possibilities available locally the government organization of the small island state of Aruba to reform. Furthermore, the starting point for the growth of the primary sector may not necessarily involve progressing further into the complicated technological and competitive world but rather stepping back to the island's traditional practices and retrofitting them to forgotten natural values.

References

- Boyer, B., Horton, J., Millán, M. F., Grosjean, C. F. R., Arias, R. E., Lopez, E. M., Wrede, P., De Kort, R. E., Ivelisse, J., & Chapman, R. (2020). *Building resilience in Aruba's food security during the COVID-19 pandemic and beyond.* World Bank.
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa
- Burns, N., & Grove, S. K. (2009). The Practice of Nursing Research: Appraisal, Synthesis, and Generation of Evidence.
- Canales, O. D. M. (2015). From Local Government to Local Governance. *Journal of Public Governance and Policy: Latin American Review, 5.*
- De Vries, M. (2013). *The challenge of good governance.* https://repository.ubn.ru.nl/handle/2066/122973
- Department of Economic Affairs, Commerce and Industry of Aruba. (2018). Entrepreneurs Development Policy for Aruba. Aruba Government. https://www.deaci.aw/wpcontent/uploads/2019/09/Entrepreneurs-Policy-2018-2021.pdf
- Food and Agriculture Organization. (2014). *Food security and nutrition in small island developing states.* https://sustainabledevelopment.un.org/content/documents/2231.pdf
- Hofman, C. L., Stancioff, C. E., Richards, A., Auguiste, I. N., Sutherland, A., & Hoogland, M. L. P. (2021). Resilient Caribbean Communities: A Long-Term Perspective on Sustainability and Social Adaptability to Natural Hazards in the Lesser Antilles. *Sustainability (Basel), 13*(17), 9807. https://doi.org/10.3390/su13179807
- Khan, S. (2014). Qualitative research method: grounded theory. *International Journal of Business and Management, 9*(11). https://doi.org/10.5539/ijbm.v9n11p224
- Kingdom of the Netherlands. (2021). *Voluntary National review on the sustainable development goals.* Ministry of Foreign Affairs of the Netherlands. https://sdgaruba.com/pages/wp-content/uploads/2022/07/Report-2022-VNR-2022-Netherlands-Report.pdf
- Lambin, É. F., & Thorlakson, T. (2018). Sustainability standards: interactions between private actors, civil society, and governments. *Annual Review of Environment and Resources, 43*(1), 369–393. https://doi.org/10.1146/annurev-environ-102017-025931
- Placci, M. F. M., & Arias, D. (2023, August 22). How to strengthen agrologistics in Caribbean countries? The case of Curaçao. *Agriculture&Food.* https://blogs.worldbank.org/en/agfood/how-strengthen-agrologistics-caribbean-countries-case-curacao
- Salimi, Y., Shahandeh, K., Malekafzali, H., Loori, N., Kheiltash, A., Jamshidi, E., Frouzan, A. S., & Majdzadeh, R. (2012, June 1). *Is Community-based Participatory research (CBPR) useful? A Systematic review on papers in a decade.* PubMed Central (PMC). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3389435/
- Sanchez-Youngman, S., Boursaw, B., Oetzel, J., Kastellic, S., Devia, C., Scarpetta, M., Belone, L., & Wallerstein, N. (2021). Structural community Governance: Importance for Community-Academic research partnerships. *American Journal of Community Psychology, 67*(3–4), 271–283. https://doi.org/10.1002/ajcp.12505
- Strand, K. (2003). Principles of Best Practice for Community-Based Research. https://quod.lib.umich.edu/m/mjcsl/3239521.0009.301?rgn=main;view=fulltext
- United Nation. (n.d.). *Small island develping states.* https://sdgs.un.org/topics/small-island-developing-states
- Wang, X. H., Van Wart, M., & Lebredo, N. (2014). Sustainability leadership in a local government context. *Public Performance & Management Review, 37*(3), 339–364. https://doi.org/10.2753/pmr1530-9576370301

Appendix I

Final report guideline, Britta Ricker, Emmeline Long (2023)

Ilse Coelman, Utrecht University

She eventually called us her adopted daughters.

I have learned a great deal, not only about Aruba and academically, but also about myself, making this an unforgettable experience. To be honest, before coming to this island for the Consultancy Project, I was slightly nervous about a few things. Especially the idea of sharing one bedroom with a roommate seemed to be challenging. However, I came here with an open mind, eager to learn to live together with others, to be open to new experiences and being more comfortable in a group. Thanks to that and the amazing group, everything turned out to be wonderful! I got along so well with my roommate, as our personalities naturally clicked. We shared thoughts about our personalities and the dynamics of our group, mutually respecting each other's need for personal space and time. This bond was a significant relief for me.

Through this experience, I've undoubtedly become more spontaneous and inclined to live in the moment. One of the highlights of my time on Aruba was my trip to Bogota, Colombia, with people I had only known for 1.5 weeks at the time, whom I now consider good friends. This adventure was not only extremely fun and spontaneous, but it also opened my eyes to the beauty and vibrancy of Latin America. Additionally, I have climbed the Hooiberg at least 6 times during my stay. And not to mention all the sunsets at the beach, the snorkelling, the dinners, and all of the other activities we did together with the group.

Of course, we had to do our consultancy project as well. This was a very nice experience, particularly due to our interactions with the people of Santa Rosa. As local group, we had to do a large amount of visits to farms and households. During these visits we were accompanied by a person of Santa Rosa, always being Facundo. Initially reserved and shy, Facundo gradually opened up to our group, a heartwarming transformation to witness. It feels like we have made very valuable relationship with him. Afterwards, Nathalie told us she had never seen him so invested in this project and so happy. Nathalie herself was incredibly kind and caring, as she for example helped us with getting a car and reminded us to put on sunscreen and enjoy ourselves during carnival. She eventually called us her adopted daughters, which was really touching.

Lastly I don't want to forget to mention the perspective I gained on teaching. Eric's teaching approach is truly remarkable, as it was always interesting and containing knowledge that will stay in my memory forever - which cannot be said of a lot of other courses. In conclusion, I would like to say that I extremely enjoyed my time here on Aruba and that I will cherish the memories.

The efficiency and feasibility of Rainwater harvesting systems in Aruba: An assessment using a multi-criteria analysis, including the preferences of the Aruban community

Ilse Coelman

Introduction

In investigating the potential of rainwater harvesting (RWH) systems to address water scarcity challenges in Aruba, it is necessary to elaborate the dynamics of implementation and adoption across national and local scale. Throughout the year, the Caribbean Island experiences distinct rainy and dry seasons; in the rainy season, a substantial amount of precipitation falls on Aruba, but a significant portion of it typically drains into the sea (Marchena & Halman, 2018). As calculated by Montoya Rodriguez (2024), the annual amount of rainfall in Aruba is an estimated 7 times the amount of water produced yearly by Water- en Energie Bedrijf Aruba (WEB). This highlights the usefulness of sustainable water management practices. RWH involves the collecting, storage, and utilization of rainwater runoff (Reijtenbagh, 2010). Implementing such a RWH system could provide a new purpose for this water. It can be used for extensive water usage by farmers, as well as the limited application of RWH systems, such as those in households and small businesses. According to Rahman et al. (2014), rainwater harvesting is the most sustainable method for water supply. It is crucial to implement sustainable solutions to reduce the impacts of global climate change, and secure a safe future for the inhabitants of Aruba, especially in small island states (Curren & Metzger, 2017).

Understanding how RWH systems can be integrated with existing water infrastructure in Aruba, while also considering the semi-arid climate of the country, requires further exploration. There is limited availability of long-term data on the performance of existing RWH systems in Aruba, which makes it challenging to assess their effectiveness and predict feasibility of future implementation of new RWH systems.

The results aim to assess the feasibility and efficiency of the existing and future potential implementation of RWH systems in Aruba, focusing on the preferences of the Aruban community. By examining factors such as economic viability, volume, life span, accessibility, and ease of both implementation and maintenance, this research strives to inform about potential implementation of RWH systems on a small and large scale. Small businesses and individual households have limited application of RWH systems, whereas farmers use RWH systems for extensive water usage according to the estimated data given by Santa Rosa, the department of Agriculture, Livestock, and Fisheries. Aruba classifies businesses with less than 10 full year equivalent employees as small enterprises (DEACI, 2018).

2. Methods

Because of the lack of previous academic knowledge on RWH systems in Aruba, the overarching approach for the methodology is based on the Grounded Theory (Bryman, 2012), meaning that the process of data collection and analysis occurred simultaneously, as clarified below.

A systematic literature review was conducted to gain a comprehensive understanding of already existing RWH systems in regions with a semi-arid climate, such as Aruba. Since there was limited academic literature about Aruba, this literature review also included gray literature, such as theses and government reports, and some unpublished data from Santa Rosa. The articles and gray literature found were categorized per sub-question. Following that, interviews were chosen as the optimal qualitative method to explore opinions on RWH system implementation among farmers and households. The interviews targeted farmers, small businesses, and households potentially benefiting from RWH systems. A small sample was drawn from existing contacts, notably in Santa Rosa, employing a snowball approach (Naderifar et al., 2017). The semi-structured interviews followed predefined guidelines but allowed interviewers the flexibility to elicit opinions and perspectives on water systems (Bryman, 2012). Analysis of the interviews included the transcription, coding and analysis of the collected data; see Negrini (2024) for more information. For this research, these interviews have been used as an initial assessment of current RWH systems present on the island and which RWH innovations are feasible, given the current situation. In line with the grounded theory approach, the interviews provided specific systems that were subjected to a multi-criteria analysis (MCA). An MCA was chosen as the optimal approach for assessing the feasibility and adaptability of potential innovations on RWH systems within the Aruban community, as only partial data is available, and the criteria that are relevant for assessment are difficult to quantify.

3. Multi-Criteria Analysis

After the interviews and systematic literature review, the following RWH systems were identified as objects for the MCA:

- Regenbak[1]
- Rain gutters made from aluminum
- Rain gutters from PVC pipes
- 3000 L – 8000 L dark tank
- Totes; discarded Intermediate bulk containers (IBCs)
- Bioswale
- Check dams
- Agroforestry
- Water pit/reservoir

3.1 Objectives, Criteria and Weights

The MCA entailed establishing a framework for integrating various assessment criteria within quantitative analysis without assigning a monetary value to every factor. The RWH systems were evaluated based on different aspects, appearing in Table 1. These aspects were defined during the literature review and correspond to codes identified in Negrini (2024). To assess the feasibility of implementation in the community, weights were given to the criteria based on the importance of each within the Aruban community, hereby reflecting the preferences of the decision makers (Sijtsma, 2006). Rankings for both equal weights and for weights based on the Aruban community were established. Then a score from 1 to 10 was decided on for every system (Taherdoost & Madanchian, 2023). A reasoned narrative for the MCA framework, the scoring and the options had to be provided (Infrastructure Australia, 2021). Then, radar diagrams were created to visualize the results. The goal of this structured approach was to identify the best solutions in terms of efficiency and feasibility that align with the socio-economic conditions of the Aruban community.

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[1] A regenbak is a reinforced concrete tank (The Caribbean Environmental Health Institute, 2009), this was a traditional rainwater harvesting system that was implemented in traditional houses before the 70's (Klomp, 1981).

Table 1; Objectives and Criteria MCA

Objective	**Sub Criteria and corresponding code**	**Weight based on preferences within the Aruban community**
Economic viability (Amos et al., 2018)	Maintenance costs *(corresponding with code in L3; **'Money'** as reason for implementation)*	8
	Initial costs *(corresponding with code in L3; **'Money'** as reason for implementation)*	9
Objective	**Sub Criteria and corresponding code**	**Weight based on preferences within the Aruban community**
System Capacity of efficient use of water (Toosi et al., 2020)	Efficient use of rainfall *(corresponding with code in L3; 'Production' as reason for implementation)*	6
	Volume (Ahmed et al., 2023) *(corresponding with code in L3; 'Production' as reason for implementation)*	6
Life Span (Infrastructure Australia, 2021)	*(corresponding with code in L3; 'lack of economic viability' as reason for implementation)*	6
Environmental impacts (Amos et al., 2018)	Evaluating the environmental impacts *(corresponding with code in L3; 'Sustainability' as reason for implementation)*	3
Accessibility (Ahmed et al., 2023)	Accessibility of material	7
	Accessibility of knowledge *(corresponding with code in L3; 'lack of knowledge')*	6
Ease of Implementation (Infrastructure Australia, 2021)	*(corresponding with code in L2; 'Limitation on implementation')*	6
Ease of maintenance (Infrastructure Australia, 2021)	*(corresponding with code in L2; 'Limitation on implementation')*	6

The objectives and criteria were obtained during the initial literature review. Criteria used appear in Table 1. The weights were determined by an analysis of the interviews conducted by the team for the consultancy project. In these interviews various opinions on the effectiveness and potential improvements were asked, as well as how the interview participant thought the general community of Aruba (of farmers) perceives the benefits and drawbacks of implementing RWH systems, what factors or incentives would motivate them or others to invest in an RWH system and why they themselves did or did not opt to implement an RWH system. The answers showed that economic viability in general was the most important factor, as most participants mentioned that current RWH systems maintenance and initial investment were too expensive. In particular the initial costs were a barrier for many people to implement an RWH system. Therefore, both the maintenance costs are weighted with an 8, and the initial costs with a 9. Another insight from the interviews was that people thought implementation would be too much work and/or that they did not have the knowledge to do so. Therefore, both ease of implementation, maintenance and accessibility of knowledge are weighed with a 6. Accessibility of material goes accompanied by both economic viability as more accessible materials are generally cheaper and by ease of implementation. Therefore, this criterion is weighed with a 7, in between scores of both other criteria. The systems' ability of efficient use of the rainfall corresponds with the ability of actual production mentioned in the interviews. Thus, these criteria are weighed with a 6. The criterion of lifespan corresponds with economic viability and is mentioned often in the interviews. However, the lifespan specifically is not mentioned as the main motivation for implementing an RWH system, resulting in a weighing of 6. Lastly, environmental savings are weighed with a 3. Few interview participants mentioned sustainability as a driver for implementation of RWH systems, and stated from an interview as answer on if sustainability is a motivation for the Aruban society to implement these kinds of systems: " few Arubans would say it's sustainable"

4. Results

Table 2 shows all the ratings given to the RWH systems for the various criteria. In this section the most important explanations concerning the scores will be highlighted. In figure 2, a link to the MCA table with further elaboration on the decision making can be found.

The regenbak has an extremely low score for initial costs and ease of implementation, due to space requirements and construction expenses, estimated at a price of US$0.74 per gallon, corresponding to 0.35AWG per liter. (The Caribbean Environmental Health Institute, 2009). From observations on the island, the volume of a regenbak ranges from 6 cubes to 30 cubes, or 6000 L to 30000 L, with outliers of 200 cubes (Beaujon & Stuivenberg, 1948). Constructing a 6000L regenbak costs 2100 AWG, excluding coating expenses, which are recommended for protection against acids and corrosion. This also leads to a reduction in water losses from cracks (Austin, 2017). Moreover, concrete production emits greenhouse gasses and involves environmental impacts from mining, transportation and processing operations. The mining for limestone and clay as raw materials and coal as fuel leads to deforestation and top-soil loss at the mining site (Mehta, 2001).

PVC and aluminum rain gutters scored a 9 for both maintenance costs and ease of maintenance, as only regular visual inspection of the pipes is needed (Caribbean Environmental Health Institute, 2009). However, their initial costs are relatively high as mentioned by R. Bareno (21 March 2024). Similarly to the regenbak, these systems are not environmentally friendly. Fossil fuel depletion and coal-based energy use for production are the most significant environmental impacts of aluminum production. The total CO_2 emissions of plastic piping systems are lower compared to pipe systems made out of competing materials. Generally, the production and transport of raw materials have the largest environmental impacts (P. Sejersen, 2016).

Table 2: Ratings given to RWH systems

	Regenbak	Rain gutters made from aluminum	Rain gutters from PVC pipes	Big tank	Totes (IBCs)	Bioswale	Check dams	Agroforestry	Water pit/reservoir
Maintenance costs (8)	4	9	9	7	6	4	5	4	6
Initial costs (9)	1	3	4	3	6	6	8	7	7
Efficient use of rainfall (6)	0	7	6	0	0	7	6	9	0
Volume (6)	8	0	0	8	6	0	0	0	7
Life Span (6)	8	6	6	7	7	7	5	8	9
Environmental savings (3)	3	4	5	5	5	8	8	10	7
Accessibility of material (7)	3	5	7	5	6	6	7	6	7
Accessibility of knowledge (6)	9	6	6	7	8	3	5	7	3
Ease of implementation (6)	2	8	4	6	8	5	6	6	5
Ease of maintenance (6)	9	9	9	9	8	7	7	4	8

In the case of Aruba, transport either by plane or ship of the final products, both the PVC and aluminum, has large CO2 emissions as well. Aluminum rain gutters scored higher for accessibility and ease of implementation, as there is a company present on the island that produces these and has the option of installment included (R. Bareno, personal communication, 21 March, 2024).

The tanks, both the bigger PVC and the totes, have similar maintenance costs and ease of maintenance. Initial costs differ, due to bigger sized tanks having more volume, thus being more expensive (Santa Rosa, 2024). Additional expenses for totes are required, as it is advised to paint the outside of the tote in darker colors for algae prevention (IBC Totes Authority, 2023 and Kooyman, 2024). The environmental impacts of the larger tanks are similar to the impacts mentioned for the PVC gutters, while totes are considered relatively sustainable, as they are second-hand discarded IBCs used for chemicals by for example Balashi and WEB (E. Mijts, personal communication, March 29, 2024). Implementation of any tank requires a potentially costly construction of a solid foundation, but the costs are dependent on weight. (The Caribbean Environmental Health Institute, 2009). The accessibility of knowledge and material is good for both types of tanks. According to personal communication with Santa Rosa (2024) and E. Mijts (29 March 2024) totes can be bought from Santa Rosa by registered farmers. Others can find these totes to be sold at Facebook or through other communication channels. They are discarded IBCs used for chemicals by for example Balashi and WEB.

Bioswales efficiently utilize rainfall, enhancing soil and groundwater infiltration while reducing runoff and urban air temperatures. Additionally, rainfall infiltration in the soil, facilitated by the bioswale, will enable the soil to grow vegetation (Wright et al., 2015). However, limited literature (Ekka et al., 2021) and lack of familiarity among interviewees pose challenges. (Interviews for consultancy report, 2024). Check dams have proven to improve groundwater recharge in semi-arid/arid countries, such as India. Additionally, they irrigate the land simultaneously (Agoramoorthy et al., 2016) Water that remains in the catchment area of the check dams can be harvested for further irrigation. For both bioswales and check dams, maintenance is needed after high velocity flows, as they can get damaged (Hassanli & Beecham, 2013).

Incorporating agroforestry improves the soil system. It enhances infiltration and water retention due to more extensive root systems. This leads to increased nutrient use efficiency of the system. It has a carbon sequestration potential, which is higher than any other RWH system. Additionally, the integration of various crops and trees into this system improves biodiversity, soil fertility, and water quality (Jose, S., 2009). Agroforestry is an upcoming topic in Aruba under the name “Syntropic Farming”. Living Soil Aruba is an agro consultancy company that gives free presentations and workshops on this practice (Living Soil Aruba - Agro Consultancy, n.d.). An agroforestry site can be implemented in any garden; maintenance includes watering, weed control, and harvesting (Godsey, L. D., 2010).

Based on personal observations, the costs, volume, environmental impacts, and ease of implementation and maintenance of water pit/reservoir systems vary greatly depending on size, resources, and space availability. Water in this kind of system tends to evaporate quickly or infiltrate into the ground (E. Kelkboom, personal communication, March 4, 2024).

From these scores, two rankings emerge. A ranking based on equal weights for every criterion, and a ranking based on weights based on the preferences of the Aruban community. These rankings provide a clear indication of which alternative performs best overall according to the criteria considered.

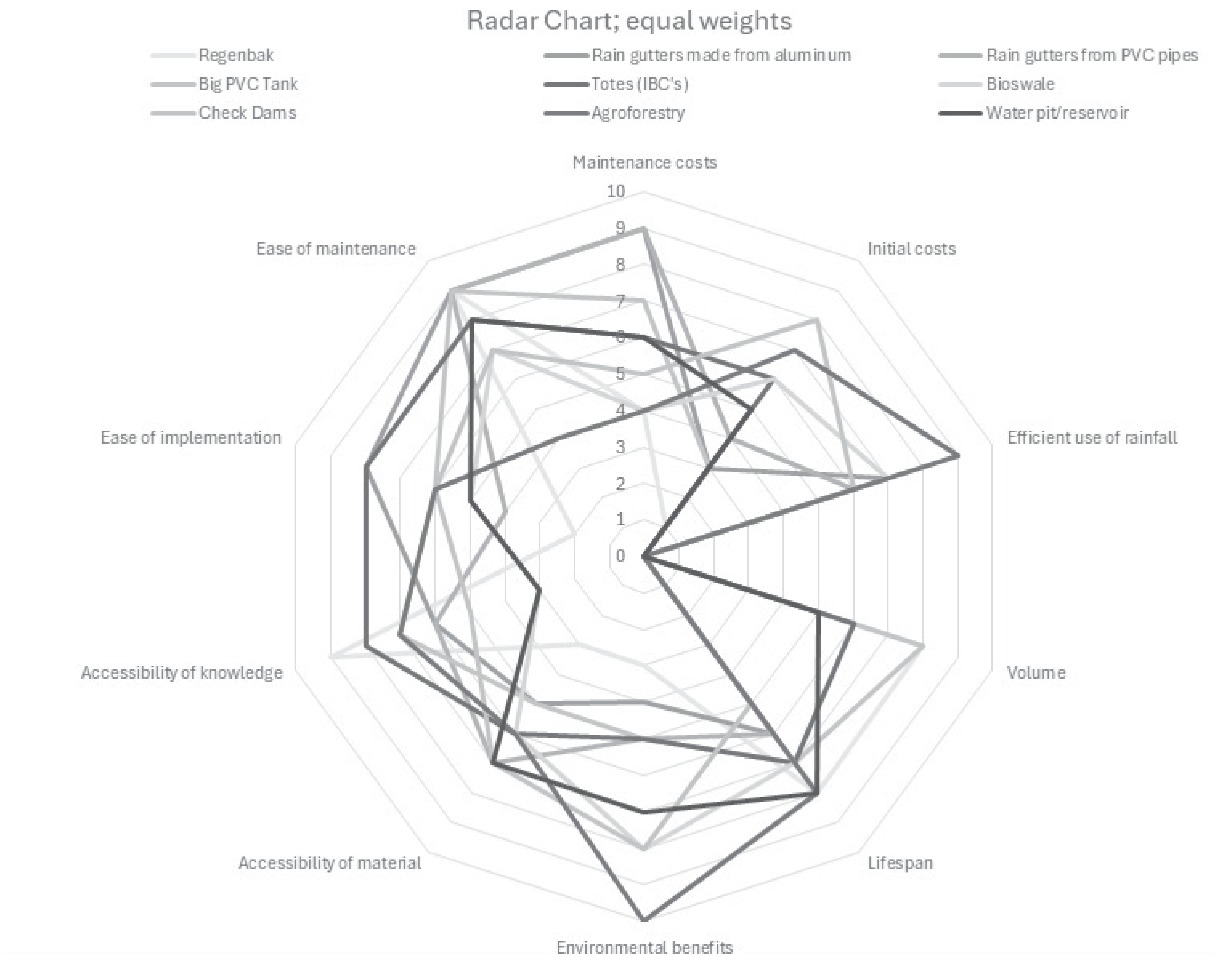
Table 3: Table with results of the MCA analysis. Two rankings are shown; one with scores based on equal weights and another based on weights including the preferences of the Aruban community.

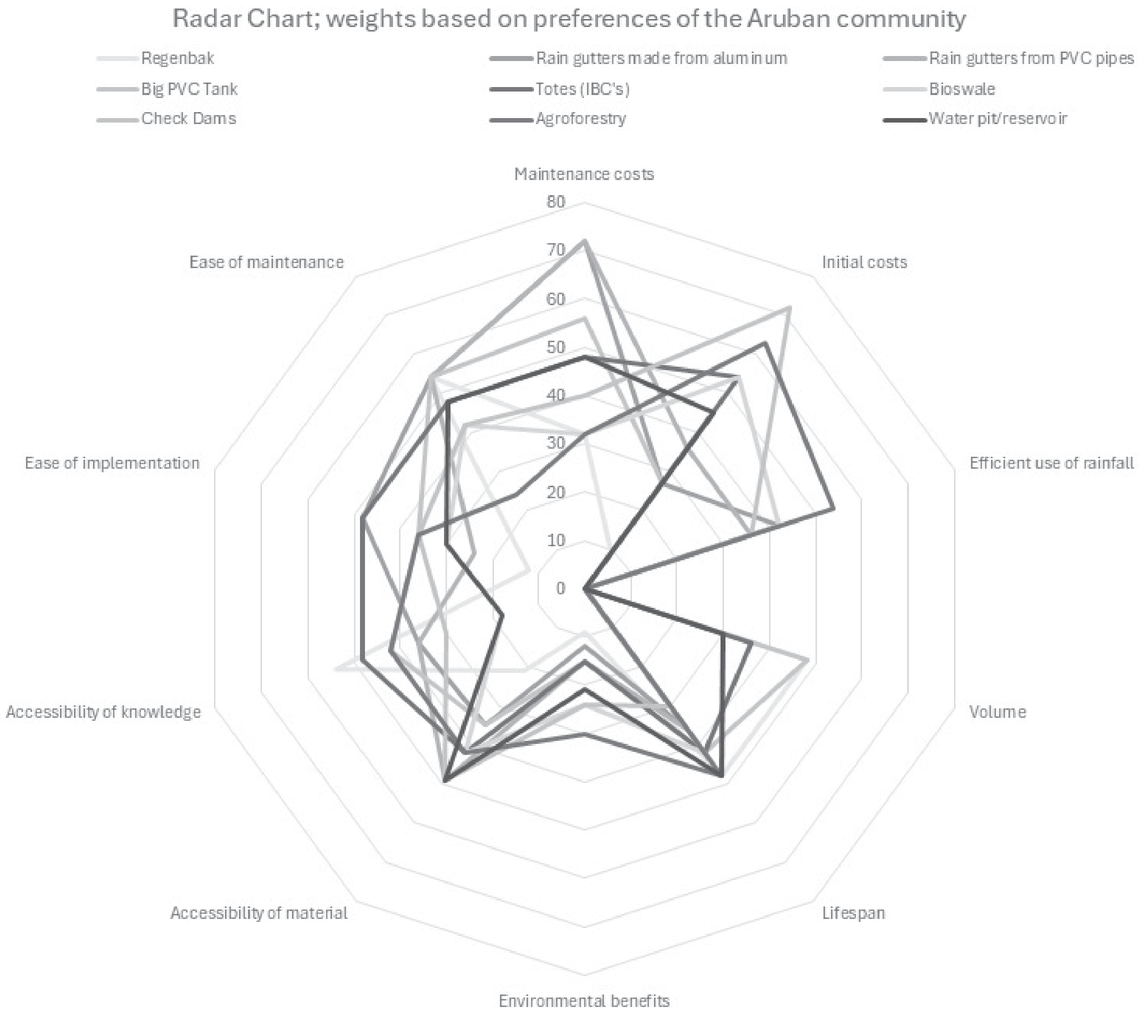
Rank	Score	Based on equal weights	Rank	Score	Based on weights including the preferences of the Aruban community
1	61	Agroforestry	**1**	381	Totes (IBCs)
2	60	Totes (IBCs)	**2**	371	Agroforestry
3	57	Rain gutters made from aluminum, 3000-8000L PVC tank, and Check dams	**3**	362	Rain gutters made from aluminum
			4	359	Check dams
			5	362	Rain gutters made from PVC pipes
4	56	Rain gutters from PVC pipes	**6**	358	3000-8000L PVC tank
5	54	Water pit/reservoir	**7**	337	Water pit/reservoir
6	53	Bioswale	**8**	326	Bioswale
7	47	Regenbak	**9**	287	Regenbak

As evident, in the weight-based ranking, the totes achieve the highest score, followed by agroforestry. Conversely, when equal weights are applied, the ranking of the totes and agroforestry is reversed. The regenbak ranks the lowest, with the bioswale following, and the water pit/reservoir taking the third-to-last position in both rankings. In both scenarios, rain gutters made from aluminum rank higher than those made from PVC pipes. The most significant divergence is seen in the ranking of the large PVC tank. The community-based weights assign it a lower rank compared to the equal weights. In terms of initial costs, which were prioritized by the Aruban community, aluminum gutters and large tanks both scored 5 points lower than check dams. Across the list of criteria, aluminum gutters and large tanks exhibit similar scores, differing by no more than 1 point, except for ease of implementation, where aluminum gutters have an advantage by 2 points due to the possibility of having them installed by a specialized party. Check dams generally receive lower scores across other criteria.

Figure 2; QR code directing to a Google Spreadsheet with the MCA table and the radar diagrams of results MCA

Figure 1; Radar diagrams of results MCA




Radar Chart; weights based on preferences of the Aruban community
Regenbak
Rain gutters made from aluminum
Rain gutters from PVC pipes
Big PVC Tank
Totes (IBC's)
Bioswale
Check Dams
Agroforestry
Water pit/reservoir
Maintenance costs
Initial costs
Efficient use of rainfall
Volume
Lifespan
Environmental benefits
Accessibility of material
Accessibility of knowledge
Ease of implementation
Ease of maintenance
80
70
60
50
40
30
20
10
0

In figure 1, two radar diagrams with the MCA results are displayed. Figure 2 is a QR code, which is also attached in Figure 2, containing the full MCA Table and the radar diagrams in color. The criteria are placed on the outside of the diagram. The inside axis displays the values of the scores that the RWH systems received. For the chart with the equal weights, it is until 10, and for the weights based on the preferences of the Aruban community it is 80. The lines in different colors correspond with the analyzed RWH systems.

The chart with equal weights shows how Agroforestry excels in efficient use of rainfall and has the lowest environmental impacts. The dark purple line of the totes lays more to the border of the circle, scoring higher across all of the criteria. The yellow line, representing the regenbak, has a peak at ease of maintenance and accessibility of knowledge, but scores low in other areas. The chart with the weights based on preferences of the Aruban community reveals outliers in the scores for initial costs of check dams and maintenance costs of rain gutters made from PVC and aluminum. In this chart the agroforestry demonstrates high scores across multiple criteria, in particular initial costs and efficient use of rainfall. Similarly, the totes score high across all criteria except for the environmental impacts.

4. Discussion & Conclusion

Firstly, it is important to note that both totes and large PVC tanks, serving as primary water storage systems, yield optimal efficiency when complemented with RWH systems, typically rain gutters. Aluminum rain gutters are preferred, ranking third in the MCA for both the weighing methods. In contrast, PVC rain gutters scored lower, largely due to their susceptibility to leakages at connection points. Aluminum gutters are produced in full length and therefore don't need connection points (R. Bareno, personal communication, March 21, 2024). Material for connecting the separate PVC gutters has to be purchased and implementation is more difficult.

Secondly, while MCA results based on Aruban community preferences offer valuable insights, it's essential to recognize potential divergence between community preferences and the optimal path for Aruba's sustainable development, potentially being the result of knowledge on these systems and most likely also on their efficiency is scarce on the island. Preferences of the community assigned the lowest weight to environmental impacts, despite this being a very important aspect for the future, highlighting a gap in awareness.

There are challenges in using an MCA that you should be aware of. The outcomes, criteria, and weights that make up the MCA framework are defined by the researcher. This configuration may be subject to unconscious or advocacy bias. Additionally, the scoring of criteria across options is likely to involve some subjectivity and this may be reflected in the scores. This was tried to mitigate by providing sufficient academic literature for the choices of objectives, criteria and weights (Infrastructure Australia, 2021).

Future research directions should be on the integration of RWH systems with the existing infrastructure of Aruba, while considering the semi-arid climate. Further research could be done on the monetary benefits of the implementation of RWH systems.

In arid regions like Aruba, such as Aruba, where water scarcity is a pressing issue (Van Sambeek et al., 2000), rainwater harvesting emerges as a potential solution. Despite perceptions of limited rainfall, calculations indicate that precipitation exceeds the yearly water production of WEB by seven times (Montoya Rodriguez, 2024). With the Earth's carrying capacity already being exceeded in six planetary boundaries (Richardson, K. et al, 2023), sustainable water management becomes critical. RWH systems not only preserve ecosystems and biodiversity but also safeguard human health by mitigating air and water pollution and limiting greenhouse gas emissions linked to climate change. The research question focuses on assessing the feasibility and efficiency of both existing and future potential implementations of RWH systems in Aruba.

The results of the MCA indicate varying degrees of feasibility and effectiveness among different RWH systems. Notably, the combination of totes with preferably aluminum rain gutters emerges as the most viable option for future implementation in Aruba. A combination of these systems is required, as a harvesting system (the gutters) is of no use without a storage system (the totes). The MCA, conducted for this consultancy report, highlights the totes superiority. They ranked first based on equal weights for the criteria and second with the weights based on the preferences of the Aruban community. The aluminum rain gutters ranked third for both the weighing methods, surpassing PVC gutters in both scenarios. The accessibility of a system is crucial for implementation, and both the totes and the aluminum gutters scored high on this criterion.

Furthermore, this study highlights the efficiency of agroforestry in rainwater utilization. This RWH system is practical and applicable to a household practice, as every interested person with a backyard could possibly implement it. The economic feasibility of this implementation is really convenient. This system merges two important aspects of rainwater harvesting systems, a durable system and efficient water collector.

Implementing RWH systems in Aruba is feasible, with certain systems proving more efficient than others considering various criteria. However, scaling up implementation requires engagement from additional stakeholders, including the government and the community. Community participation is crucial for the implementation of these systems. Creating awareness involves promoting every aspect of sustainability, showing benefits and ensuring financial profitability. Ideally, alternative norms and values have to be established, achieved by a paradigm shift towards environmentally conscious decisions and practices. Building community engaged awareness is fundamental for effectively promoting and convincing people to adopt scientifically based decisions. Thus, a combination of further research on potential future implementation of RWH systems and creating community awareness would be beneficial on the feasibility of the implementation of RWH systems in Aruba.

5. References

- Abbasi, S., *Vaezin*, S. M. H., Samani, A. N., & Bozorg-Haddad, O. (2020). *Spatial Assessing of cost-effectiveness of check-dams in controlling sediment load*. University of Tehran. https://www.researchgate.net/publication/340384306_Spatial_Assessing_of_cost-effectiveness_of_check_dams_in_controlling_sediment_load_Case_study_Kond_watershed
- Agarski, B., Vukelić, D., Mićunović, M. I., & Budak, I. (2019). Evaluation of the environmental impact of plastic cap production, packaging, and disposal. *Journal of Environmental Management, 245*, 55–65. https://doi.org/10.1016/j.jenvman.2019.05.078
- Agoramoorthy, G., Chaudhary, S., Chinnasamy, P., & Hsu, M. J. (2016). Harvesting river water through small dams promotes positive environmental impact. *Environmental Monitoring and Assessment, 188*(11). https://doi.org/10.1007/s10661-016-5640-5
- Ahmed, S. A., Jesson, M., & Sharifi, S. (2023). Selection Frameworks for Potential Rainwater Harvesting Sites in Arid and Semi-Arid Regions: A Systematic Literature Review. *Water, 15*(15), 2782. https://doi.org/10.3390/w15152782
- Amos, C. C., Rahman, A., & Gathenya, J. M. (2018). Economic analysis of rainwater harvesting systems comparing developing and developed countries: A case study of Australia and Kenya. *Journal of Cleaner Production, 172*, 196–207. https://doi.org/10.1016/j.jclepro.2017.10.114
- Austin, J. (2017). *Tank Coatings and Maintenance* (The SUEZ Canal Company, Ed.) [Slide show; Powerpoint]. https://www.rusa-or.org/files/4c728ec47/Concrete+%26+Steel+Tank+Maintenance.pdf
- Beaujon, R. J., & Stuivenberg, P. A. (1948). *De Landswatervoorzieningsdienst*. https://ia803106.us.archive.org/30/items/BNA-DIG-KOSTBARE-0165-ARUBA-05-LWV/BNA-DIG-KOSTBARE-0165-ARUBA-05-LWV.pdf
- Bowling, J., Tattersfield, S., & Darakjian, T. (2011). Triple bottom line assessment of rooftop catchment system. In *UBC Social Ecological Economic Development Studies (SEEDS) Student Report*. University of British Columbia. https://doi.org/10.14288/1.0108625
- Bryman, A. (2012). Social research methods. Fourth edition. Oxford University press.
- Curren, R., & Metzger, E. (2017). Living well now and in the future: Why sustainability matters. *MIT Press.*
- Department of Economic Affairs, Commerce and Industry of Aruba. (2018). Entrepreneurs Development Policy for Aruba. In https://www.deaci.aw/wp-content/uploads/2019/09/Entrepreneurs-Policy-2018-2021.pdf. Aruba Government. https://www.deaci.aw/wpcontent/uploads/2019/09/Entrepreneurs-Policy-2018-2021.pdf
- Ekka, S. A., Rujner, H., Leonhardt, G., Blecken, G., Viklander, M., & Hunt, W. F. (2021). Next generation swale design for stormwater runoff treatment: A comprehensive approach. *Journal of Environmental Management, 279*, 111756. https://doi.org/10.1016/j.jenvman.2020.111756
- Everhart, G. J. (2010). *Comparison of Life-Cycle Energy of Water Storage Tanks* [Graduate Thesis, University of Florida]. https://ufdcimages.uflib.ufl.edu/UF/E0/04/25/73/00001/everhart_g.pdf
- Ghimire, S. R., Johnston, J. M., Ingwersen, W. W., & Sojka, S. (2017). Life cycle assessment of a commercial rainwater harvesting system compared with a municipal water supply system. *Journal of Cleaner Production, 151*, 74–86. https://doi.org/10.1016/j.jclepro.2017.02.025
- Godsey, L. D. (2010). Economic budgeting for agroforestry practices. In *AGROFORESTRY IN ACTION*. University of Missouri Center for Agroforestry. https://centerforagroforestry.org/wp-content/uploads/2021/05/af1006.pdf
- Hassanli, A. M., & Beecham, S. (2013). *Criteria for optimizing check dam location and maintenance*

requirements (Doctoral dissertation, Nova Science). https://www.researchgate.net/profile/Ali-Hassanli/publication/287636490_Criteria_for_optimizing_check_dam_location_and_maintenance_requirements/links/56a6bb6508ae860e0253cf4c/Criteria-for-optimizing-check-dam-location-and-maintenance-requirements.pdf

- Infrastructure Australia. (2021). Guide to Multi-Criteria Analysis: Technical guide of the Assessment Framework. ISBN: 978-1-925352-54-2
- Jose, S. (2009). Agroforestry for ecosystem services and environmental benefits: an overview. *Agroforestry Systems, 76*(1), 1–10. https://doi.org/10.1007/s10457-009-9229-7
- Klomp, A. (1981). *Het "oude" Bonairiaanse woonhuis.* Koninklijk Instituut voor Taal, Land- en Volkenkunde. https://www.researchgate.net/publication/47433463_Het_%27oude%27_Bonairiaanse_woonhuis/fulltext/588b714b45851567c93c5846/Het-oude-Bonairiaanse-woonhuis.pdf
- Kooyman. (n.d.). *Eslon Half Round Gutter Type 150 4 m PVC Grey.* https://www.kooymanbv.com/aruba_en/eslon-pvc-half-round-gutter-type-150-4-meter-length-grey100003656.html
- Living Soil Aruba - Agro Consultancy. (n.d.). *Living Soil Aruba.* https://www.livingsoilaruba.com/home
- Marchena, F. A., & Halman, J. I. (2018). Aruba's desalination's knowledge and experience: Conquering the sea toward desalination's sustainability. *AQUA-LAC, 10*(1), 39–50. https://doi.org/10.29104/phi-2018-aqualac-v10-n1-04
- Mehta, K. P. (2001). Reducing the environmental impact of concrete. *Concrete international, 23*(10), 61-66. http://ecosmartconcrete.com/docs/trmehta01.pdf
- Montoya Rodriguez, Y. (2024) The value of rainwater: The economic viability of rainwater harvesting systems in Aruba, in *Mijts & Ballantyne UAUCU Student Research Exchange Collected Papers 2024*
- Naderifar, M., Goli, H., & Ghaljaie, F. (2017). Snowball sampling: a purposeful method of sampling in qualitative research.,14(3). https://doi.org/10.5812/sdme.67670
- Negrini, G. (2024) Farming community and government interaction: a case study of the community perspective on the role of the Aruban government, in *Mijts & Ballantyne UAUCU Student Research Exchange Collected Papers 2024*
- Osouli, A., Bloorchian, A. A., Grinter, M., Alborzi, A., Marlow, S. L., Ahiablame, L., & Zhou, J. (2017). Performance and cost perspective in selecting BMPs for linear projects. *Water, 9*(5), 302. https://doi.org/10.3390/w9050302
- P. Sejersen. (2016). Comparative Life Cycle Assessment of a PVC-U rain gutter system versus a system made from galvanized steel. *Plastic Pipes Conference* (18th ed.). TEPPFA, Berlin.
- Pal, D., Galelli, S., Tang, H., & Ran, Q. (2018). Toward improved design of check dam systems: A case study in the Loess Plateau, China. *Journal of Hydrology, 559*, 762–773. https://doi.org/10.1016/j.jhydrol.2018.02.051
- Patrick, S. (2005). *Practical guide to polyvinyl chloride.* iSmithers Rapra Publishing. (p. 3)
- Rahman, S., Khan, M. T. R., Akib, S., Din, N. B. C., Biswas, S. K., & Shirazi, S. M. (2014). Sustainability of rainwater harvesting system in terms of water quality. T*he Scientific World Journal, 2014.* 10.1155/2014/721357
- Reijtenbagh, R. (2010). Minimum design requirements for domestic rainwater-harvesting systems on small volcanic islands in the Eastern Caribbean to prevent related water quality and quantity issues. http://resolver.tudelft.nl/uuid:06a2ebaf-78a3-44f2-a3bb-e0d491aa8c5f
- Richardson, K., Steffen, W., Lucht, W., Bendtsen, J., Cornell, S.E., Donges, J.F., Drüke, M., Fetzer, I., Bala, G., von Bloh, W., Feulner, G., Fiedler, S., Gerten, D., Gleeson, T., Hofmann, M., Huiskamp, W., Kummu, M., Mohan, C., Nogués-Bravo, D., Petri, S., Porkka,

M., Rahmstorf, S., Schaphoff, S., Thonicke, K., Tobian, A., Virkki, V., Weber, L. & Rockström, J. 2023. Earth beyond six of nine planetary boundaries. *Science Advances 9,* 37.

- Sendanayake, S. (2016). Life cycle analysis of ferro-cement rainwater tanks in Sri Lanka: A comparison with RRC and HDPE tanks. *International Journal of Applied Engineering Research, 12*(2), 1-8.
- Sijtsma, F. J. (2006). *Project evaluation, sustainability and accountability: combining cost-benefit analysis (CBA) and multi-criteria analysis (MCA).* [Thesis fully internal (DIV), University of Groningen]. Stichting Ruimtelijke Economie Groningen, Rijksuniversiteit Groningen
- Sran, D. S., Kukal, S. S., & Singh, M. J. (2012). Run-off and sediment yield in relation to differential gully-plugging schemes in micro-catchments of Shiwaliks in the lower Himalayas. *Archives of agronomy and soil science, 58*(11), 1317-1327. DOI: https://doi.org/10.1080/03650340.2011.577422
- Taherdoost, H., & Madanchian, M. (2023). Multi-Criteria Decision Making (MCDM) methods and Concepts. *Encyclopedia, 3*(1), 77–87. https://doi.org/10.3390/encyclopedia3010006
- The Caribbean Environmental Health Institute. (2009). *Handbook on Rainwater Harvesting for the Caribbean: A practical guideline featuring best practices for rainwater harvesting in small island Caribbean.* United Nations Environment Programme and the Caribbean Environmental Health Institute. https://www.pseau.org/outils/ouvrages/cehi_handbook_for_rainwater_harvesting_for_the_caribbean_2009.pdf
- Toosi, A. S., Tousi, E. G., Ghassemi, S. A., Cheshomi, A., & Alaghmand, S. (2020). A multi-criteria decision analysis approach towards efficient rainwater harvesting. *Journal of Hydrology, 582,* 124501. https://doi.org/10.1016/j.jhydrol.2019.124501
- University of Missouri Center for Agroforestry. (2021). *Training Manual for Applied Agroforestry Practices.* https://centerforagroforestry.org/wp-content/uploads/2021/09/Chapter-2-Planning-Agroforestry-UMCA-AF-Training-Manual.pdf
- Van Sambeek, M., Eggenkamp, H., & Vissers, M. (2000). The groundwater quality of Aruba, Bonaire and Curaçao: A hydrogeochemical study. *Netherlands Journal of Geosciences, 79*(4), 459-466. doi:10.1017/S0016774600021958
- Wright, K., Koo, J., & Beldy, A. (2015). *Enhancing Resilience in Boston: A Guide for Large Buildings and Institutions.* A Better City. https://www.abettercity.org/docs/resiliency%20report%20web%20FINAL.pdf
- Zhang, Y., Sun, M., Hong, J., Han, X., He, J., Shi, W., & Li, X. (2016). Environmental footprint of aluminum production in China. *Journal of Cleaner Production, 133,* 1242-1251. https://doi.org/10.1016/j.jclepro.2016.04.137

9 songs. 9 faces. 9 spaces.

Yoshi Montoya Rodriguez, Utrecht University

I even did a Papiamento course.

Aruba, a place I have the privilege of considering my home for two and a half months. It has been one of the most amazing experiences till now, on a personal and academic level. I have always had this urge to travel and explore different parts of the world, which sparked an interest for doing an exchange during my bachelor. However, due to my track choice “Business & Innovation”, it was not really possible for me to go on an exchange in the first half of my third year. I was very disappointed about that but fortunately there was the option to do a consultancy project in Aruba. I didn’t hesitate for long and made a video with my motivation, a few days later I got in! I have to say that this experience has been even better than I expected. In the past two and a half months, I have met some amazing people that I can call my friends now, and I’ve also done several different kinds of sports, such as beach tennis, beach volleyball and windsurfing. I participated in a beach tennis tournament, while I didn’t even now this sport existed before coming here. I even did a Papiamento course, and completed the course by doing a small presentation in Papiamento. We got a certificate, and a hopi dushi local meal after completing the course.

Although I’ve done a lot of fun activities, I also knew this program would bring me a lot of academic opportunities. Our collaboration with Santa Rosa has thought me a lot of different things, such as how to work together with the community and how to approach people in interviews, to get the best results as possible. During our research, I also learned how to communicate really well in a group and work closely together, taking account everyone’s different personalities and working styles. I’m very happy with the group I had to do the research with, because I feel like we are all very different but at the same time that complemented each other really well! Additionally, I’ve had the luck to share this whole experience with a very good friend of mine, who has become even closer to me after this experience.

I will definitely miss living in a bikini and ending the day with watching sunset at the beach. Besides the beautiful nature, I will also miss the wonderful people that I have had the privilege of getting to know along the way. In general, this experience has been a very valuable experience for me and I will definitely come back sometime in the future. Masha danki, ayo!

The value of Rainwater
The economic viability of rainwater harvesting systems in Aruba.

Yoshi Montoya Rodriguez

Introduction

Rainwater is a naturally occurring relatively clean and abundant source of water in many locations. Rainwater harvesting (RWH) systems involve capturing the rain before it becomes surface water, minimizing pollution and capturing its potential energy. It can improve water security in the face of uncertain future climate patterns. There has been an increased interest in RWH in both developing and developed nations. However, there is little research on the economic viability of RWH in developing countries (Amos et al., 2018). Studies assessing the economic feasibility of RWH systems often overlook developing nations, particularly small island developing states (SIDS). The categorization of SIDS as a distinct group of developing countries dates back to the Earth Summit in Rio de Janeiro, Brazil, in 1991 (Gheuens et al., 2019). According to the definition from the International Monetary Fund (IMF), Aruba is a developing country because of its lower economic performance, with an average annual income of 33,410 USD, which is equal to 64,147.20 Aruban Florin (WorldData, 2024).

Water- en Energiebedrijf Aruba (WEB) N.V. is the only water and power producer on the island of Aruba, which means that the population is completely dependent on them. WEB can be classified as a monopoly, which is a company that dominates the market. A monopoly tends to set higher prices than a competitive market leading to a lower consumer surplus. Additionally, monopolies can gain political power and the ability to shape society in an undemocratic and unaccountable way (Zhaldak & Somova, 2023). In Aruba the average water use per person is 150 Liters a day, which is about 5000 liters per month. The average domestic use for a 4-person household in Aruba is about 21 m3 per month, which is equal to 215.70 Aruban Florin (AWG) per month (WEB Aruba N.V. | Water- En Energiebedrijf Aruba N.V., 2024a). At the same time, the minimum wage in Aruba is 1893,40 AWG per month (Government of Aruba, 2023), which means that only the cost of water is already 11,4% of the monthly income for people receiving the minimum wage.

Moreover, the annual amount of rainfall in Aruba is 7 times the amount of water produced by WEB yearly. This can be calculated by multiplying the average annual amount of rainfall in Aruba, by the area of Aruba. According to the Departamento Meteorologico Aruba (2020), the average rainfall between 1981-2010 was 471,7 mm. Furthermore, Aruba has an area of 178,92 square kilometres (Aruba Island, 2024). Each mm/m2 is 1 litre, so a square kilometre is 1 million square metres (UnitConverters, 2024). Then you get 178,920,000 m2 * 471,7/1000 (to get to cubic meters) is approximately 84,40 million cubic meters. WEB Aruba N.V. produces 33,000 cubic meters per day for consumption, which is roughly 12 million cubic meters per year (WEB Aruba N.V. | Water- En Energiebedrijf Aruba N.V., 2024b). When dividing 84,40 million cubic meters by 12 million cubic meters, the annual amount of rainfall in Aruba is 7 times the amount of water produced by WEB yearly (Mijts, personal communication, 2024). Thus, there is a big potential for rainwater harvesting on the island of Aruba.

This paper is written in relation to the consultancy project conducted for the consultant client, Santa Rosa, concerning the implementation of rainwater harvesting systems. The focus of this paper is on assessing the economic viability of RWH systems, specifically in Aruba. Its findings aim to inform potential future deployments of RWH systems on both small and large scales. Economic viability refers to the capacity of a system to generate income and uphold its long-term sustainability. The profit (or return) can reasonably be expected to be high enough to justify the investment. For a project to be economically viable, its benefits must outweigh its costs when considering societal impacts, including externalities and environmental factors. While project revenue is a starting point, the actual benefits to society can often exceed initial estimates (Cortes & Mayrhofer, 2019). Thus, the research question for this paper: How economically viable is the implementation of rainwater harvesting systems in Aruba?

Methodology

Due to the lack of information regarding rainwater harvesting systems in Aruba, the methodology will primarily follow the Grounded Theory approach (Bryman, 2012), where data collection and analysis happen concurrently. Furthermore, a systematic literature review is conducted to gain a comprehensive understanding of already existing RWH systems and their characteristics. The searches will be executed in the databases of Utrecht University, and the database of Santa Rosa. Since there is limited academic literature about this topic in Aruba, the literature review also includes grey literature such as theses and some unpublished data from Santa Rosa. Additional data is gathered from interviews with households, farmers, and small businesses that were conducted; for the consultancy project done for Santa Rosa. Small enterprises in this context are businesses with less than ten full-year equivalent employees (DEACI, 2018).

In these interviews various things were asked, such as how the interviewee perceives the costs and benefits of implementing RWH systems, what factors or incentives would motivate them or others to invest in an RWH system and why they did or did not opt to implement an RWH system. The answers showed that economic viability in general was the most important factor, as most interviewees mentioned that current RWH systems investments and O&M costs were too expensive. In particular the initial costs were a barrier for many people to implement an RWH system.

Additionally, a cost-benefit analysis was chosen as the best approach for assessing the economic viability of the potential implementation of RWH systems. A cost-benefit analysis (CBA) is a systematic process used to evaluate decisions and determine which actions to take (Hayes, 2024). A CBA for rainwater harvesting systems in SIDS would involve evaluating the financial costs and benefits associated with implementing such systems. The costs of implementing a RWH system can be broken down into initial investment, maintenance costs, operational costs, and capital costs. The initial investment is the cost of installing rainwater harvesting infrastructure including gutters, tanks, pipes, and filtration systems. Moreover, the maintenance costs are the ongoing expense for cleaning, repairs, and replacing parts over the lifespan of the system. Furthermore, the operational costs include costs associated with pumping, treatment, and distribution of harvested water. Lastly, the capital costs can be considered, which includes the cost of land or space required for installation. Besides the costs, the implementation of RWH systems has benefits, which can be estimated. The benefits include water savings, reduced water bills, environmental benefits, social benefits, and economic benefits. This paper will focus on the economic costs and benefits of implementing a rainwater harvesting system.

Results

Average income, property area, and roof area

According to the data gained from the survey, the average roof area and the average property area of the properties of respondents were calculated, as shown in Table 1. The average roof area of households, farmers, and small businesses in Aruba is 200 square meters, and the average property area is 750 square meters. It must be noted that the calculated averages are based on the ranges used in the survey on Rainwater Harvesting in Aruba [Unpublished raw data].

Table 1: The calculated average roof and property area, based on the data gathered from the survey.

Range	**Amount of respondents**	**Total average roof area (m2)**	**Range**	**Amount of respondents**	**Total average property area (m2)**
0 – 50	2	50	0 - 100	2 (10%)	
50 – 100	8	600	100 - 500	6 (30%)	
100 – 500	8	2400	500 – 1000	10 (50%)	
500 – 1000	1	750	1000 – 2000	0	
1000+	0	0	2000 – 5000	1 (5%)	
			5000 – 10000	1 (5%)	
			10000+	0	
Prefer not to say	2	0	Prefer not to say	0	
Total	19	3800	Total	20 (100%)	Median of the ranges calculated in excel
Average per respondent	**1**	**200**	**Average per respondent**	**1**	**750**

According to an investigation by Nel et al. (2017), the utilization of supplementary water sources such as rainwater, groundwater, and greywater for non-potable purposes in large properties exceeding 1,000 m2 could result in a significant reduction in municipal water demand, ranging from 55% to 69%. While acknowledging RWH's potential to enhance water supply, studies often emphasize that the costs associated with these systems frequently exceed their benefits (Abdulla, 2019 & Campisano et al., 2017). This is especially evident for households with roof areas less than 1,000 m2. The financial challenges of implementing RWH systems at the household level are attributed to factors such as high initial investment, limited storage capacity, water quality concerns, and, in certain regions, insufficient rainfall duration, which raises long-term reliability concerns.

Based on the results of the survey on Rainwater Harvesting in Aruba [Unpublished raw data], the average annual income in Aruba is 47.284 AWG. It must be noted that an assumption has been made for the 47 respondents who earn more than 50.000 AWG per year (Diaz-Maroto Knöfler et al., 2024), to be able to calculate the average annual income. A limit of 80.000 AWG has been added to the range of 50.000+ AWG, which gives the average annual income of 47.284 AWG. As mentioned in the introduction, the minimum wage in Aruba is 1893,40 AWG per month (Government of Aruba, 2023), which means that the minimum annual income is 22.720,80 AWG. The calculated average annual income of 47.284 AWG is more than twice as much as the minimum wage in Aruba. Thus, it can be concluded that the respondents of the survey are relatively wealthy citizens.

Cost-Benefit Analysis

The economic viability of RWH implementation is heavily influenced by the cost of potable water in the area (Abdulla, 2019 & Amos et al., 2018). In Aruba, where the average domestic monthly water usage for a four-person household is approximately 21 m3, constituting 11.4% of the minimum wage earner's monthly income, the cost of water is significant (WEB Aruba N.V., 2024a). This cost is determined by WEB, which holds a monopoly in municipal water production on the island. The costs of potable water provided by WEB are locally perceived as expensive (backed up with evidence from survey and interviews). To reduce the dependence and monthly water bills by WEB, a cost-benefit analysis is done for the potential implementation of various RWH systems on Aruba (Table 2).

Table 2: The costs of the potential implementation of RWH systems.

	Regenbak (Cistern)	**Rain gutters made from aluminum**	**Rain gutters made from PVC pipes**	**Big PVC tank**	**Totes (IBC's)**	**Bioswale**	**Check dams**	**Agroforestry**	**Water pit/reservoir**
Initial investment	1,33 AWG per gallon	50 AWG per meter, including installation. 40 AWG per meter, excluding installation	90.95 AWG per 4 meters. However, material for connecting the separate gutters also has to be bought (35,36 AWG per gutter connection)	1000 – 1500 AWG per tank (3000 – 8000 liter)	75 – 150 AWG per tote (1000 liter)	104,40 AWG per linear ft for 9-16 ft wide patches, which is 32,04 AWG per m for 2.7 to 4.9 m wide patches	Preparation costs. Cost-effectiveness increases with lower height, larger number of check-dams is cheaper	Costs include ground preparation and planting crops	Costs of excavation, dependent on size of reservoir/pit
Operation & Maintenance costs	Costs of maintenance can include repairing of cracks and re-coating the inside of the tank to prevent cracking and leakage	Smooth metal has higher runoff coefficients, wo need less maintenance, due to less sediment accumulation	There is no need to regularly clean the gutters to reduce debris collection	Most PVC tanks are already dark colored. Therefore, no painting is required.	To prevent the tote from algae growth, it is advised to paint the outside of the tote in darker colors. This can be achieved with any dark-colored PVC paint, prices typically ranging from 50 AWG to 150 AWG	7,76 AWG per square ft, corresponding with 0,72 AWG per square meter	The sediment load has to be removed after rainfall. Additionally, check dams less than 2 meters high have unsignificant maintenance costs	Maintenance costs are expressed in time, as maintaining any type of garden costs time	Dependent on the size
Total costs	**0,35 AWG per liter + O&M costs**	**40 AWG per meter or 50 AWG per meter + O&M costs**	**22,74 AWG per meter + 35,36 per gutter connection every 4 meters)**	**0,188 per liter (8000 liter tank) -0,330 per liter (3000 liter tank)**	**0,125 – 0,300 AWG per liter**	**32,04 AWG per m for 2.7 to 4.9 m wide patches + 0,72 AWG per square meter**	**Preparation costs + O&M costs**	**Ground preparation and planting crops + O&M costs**	**Costs of excavation + O&M costs**

The expenses associated with potentially implementing RWH systems in Aruba are outlined in Table 2. A distinction is made between initial investment and the operation & maintenance (O&M) costs. The initial investment involves the starting capital required for the implementation of a system (Mitchell, 2024). While most costs are expressed in monetary terms, certain RWH systems like check dams, agroforestry, and water pit/reservoir are not quantified in monetary values. The operational and maintenance costs of agroforestry are measured in time, considering time as a valuable resource (Oxley & Baete, 2012). However, if time is not deemed as a cost, agroforestry emerges as one of the most economically viable RWH systems to adopt.

It must be noted that the monetary costs are converted into AWG, using a conversion rate of 1 US dollar equal to 1.80 AWG (WorldData, 2024). To be able to make a comparison among RWH systems, all monetary costs are standardized into a common unit or a similar one. For instance, the initial investment for a 'Regenbak' is 1.33 AWG per gallon, which is then converted to 0.35 AWG per liter, based on the conversion factor of 1 gallon equaling 3.785 liters (UnitConverters, 2024). Thus, the initial investment for a 'Regenbak' becomes 1.33 AWG divided by 3.785 liters, resulting in 0.35 AWG per liter.

Table 3: Two rankings based on the monetary costs, shown in Table 2.

Rank	**1: Based on total costs in AWG per liter**	**2: Based on total costs in AWG per meter**
1	Totes (IBC's)	Bioswale
2	Big PVC tank	Rain gutters (Aluminum)
3	Regenbak (Cistern)	Rain gutters (PVC)

Two rankings can be established using the monetary values presented in Table 2. The first ranking is based on total costs in AWG per liter and the second ranking is based on total costs in AWG per meter, as shown in Table 3. The costs per tank, totes, and rain gutters remain fixed regardless of the quantity purchased. While it's plausible that purchasing in bulk might lead to lower unit costs through negotiation, but no bulk purchase discount is assumed in this analysis.

Besides, the costs mentioned in Table 2, the implementation of RWH systems, all have its benefits. Information about the monetary benefits of implementing the RWH systems is lacking in the CBA, due to the lack of data in Aruba. There is too little information available about the monetary benefits of these rainwater harvesting systems. Other benefits of these RWH systems, such as environmental benefits and accessibility, are explained in the Multi-Criteria Analysis (Coelman, 2024).

After having implemented RWH systems, there will be a decrease in the amount of water needed from WEB, which will decrease the monthly water bill. According to Juliana et al. (2017), the implementation of RWH systems provides an environment and financial benefits. The more rainwater used, the more the benefits. Based on the simulation outcomes, it can be seen that with the higher use of rainwater, the RWH system will become more profitable as more benefits are generated. As these RWH systems mature, the benefits they provide are expected to surpass the associated costs (Juliana et al., 2017).

Water captured by rainwater harvesting does not increase property owners' overall water use but results in a permanent reduction in water purchased from WEB. There is no rebound effect assumed. A rebound effect occurs when an improvement in technology does not result in net savings but instead users increase their water use. This phenomenon shows how the gains from being more efficient can be offset by a rise in demand for resources. In the case of rainwater harvesting, the mitigation of WEB water usage may not necessarily correspond to an absolute reduction in total water usage. A rebound effect could challenge the feasibility of an absolute decoupling between economic growth and resource use (Saey-Volckrick, 2020).

Volume, lifespan, and payback period

Studies in different regions have highlighted the time required to offset the installation costs of RWH systems, ranging from 5 to 45 years depending on factors such as rainfall, roof size, and water-saving technology (Abdulla, 2019 & Juliana et al., 2017). In Brazil, research indicated payback periods of 6 to 10 years for small and large buildings, respectively (Cardoso et al., 2020). Table 4 provides an overview of the volume and lifespan of the RWH systems included in this research.

Table 4: An overview of the volume and lifespan of the RWH systems.

	Regenbak	**Rain gutters made from aluminum**	**Rain gutters made from PVC pipes**	**Big PVC tank**	**Totes (IBC's)**	**Bioswale**	**Check dams**	**Agroforestry**	**Water pit/reservoir**
Volume	The volume of regebakken can range from 6 cube to 30 cube, which is 6000 L to 30000 L. With outliers of 200 cube.	Dependent on storage unit it is combined with.	Dependent on storage unit it is combined with. It is suitable for roof sizes up to 185 m2.	3000 – 8000 liters	1000 liters	Inapplicable	Inapplicable	Inapplicable	The volume of this type of RWH system varies extremely and is dependent on the resources and space of the location.
Lifespan	Well-constructed reinforced concrete tanks can have a useful lifetime of 50 years. However, from observations, various regenbakken were still intact since their initial installment (before 1960).	40+ years, however it is dependent on environmental factors such as wind, acidity of the rain, and sunlight.	50 years, dependent on environmental factors. These pipes cannot be manufactured in full length, therefore other materials (with a shorter lifespan) are necessary for the connections.	PVC used for construction materials, including water storage tanks, has a life span of more than 40 years.	When totes are used only to store water, their useful lifespan can extend for many years.	Extensive, depending on continued maintenance.	A high sediment scenario is used, as rainfall in Aruba tends to cause runoff including sediment. The life expectancy of check dams with high sediment input is lower than 20 years.	When being maintained, agroforestry will have a long life span.	No limits when maintained properly. However, heavy rainfall can cause sediment flows to fill up the reservoir.

The lifespan of each RWH system is dependent on multiple factors, such as location, maintenance, and environmental factors. Due to the lack of data on the monetary benefits, estimations can be made on the payback period. In a context where the cost of water is 20 AWG per cubic meter, an initial investment of 6000 AWG would already pay of, when 300 cubic meters of water would be harvested. This amount if equivalent to three years' worth of rainfall for a 200 square meter house, assuming optimal capture conditions. Allowing for a 50% loss rate, the investment is expected to yield returns within six years (Mijts. Personal communication, 2024). A long payback period of RWH systems diminishes their appeal to consumers and utilities, resulting in limited adoption. This prolonged period is primarily due to the low water charges, which are set based on the idea that water is a societal necessity (Hajani and Rahman, 2014). The lower the payback period, the more attractive the investment becomes (Silva et al., 2015).

Discussion

As mentioned before, calculations reveal that rainfall surpasses the annual water production of WEB by a factor of 7 (Mijts, personal communication, 2024). As Aruba faces challenges with water scarcity due to its arid climate, there is a big potential for the implementation of RWH systems. Not only the dependency on WEB decreases, but it also reduces the water costs of the Aruban inhabitants. In discussing the economic viability of RWH systems in Aruba, it is essential to address some points due to the lack of comprehensive data on the monetary values of the costs and benefits of the RWH systems.

Given the scarcity of data specific to Aruba, some costs of RWH systems are estimated based on research conducted in other regions with differing climates. While this provides a basis for analysis, it is crucial to recognize the potential variability in costs due to factors, such as labor rates and environmental conditions. It must also be noted that assumptions and calculations are made by the researcher. Mistakes in calculations are possible and the accuracy of these values depends on the reliability of the data and methodologies used. Providing academic literature as a basis for these calculations mitigates potential errors but there are still assumptions made by the researcher.

Furthermore, the results of the survey and interviews may not fully represent the diversity of the Aruban community. For instance, the calculation of the average annual income is based on the annual income of the 81 survey respondents of the survey on Rainwater Harvesting in Aruba [Unpublished raw data]. The calculated average annual income of 47.284 AWG is more than twice as much as the minimum wage in Aruba, which suggests that the survey respondents are relatively wealthy citizens.

Despite the benefits of implementing RWH systems, various socio-economic and physical blockages have been found to hinder the success of RWH systems in developing regions (Ndeketeya & Dundu, 2019). Operational and maintenance costs may vary significantly due to environmental factors, such as wind and sunlight, affecting the overall economic feasibility of RWH implementation. There is a clear need for additional research on the monetary benefits, and consequently the payback periods specifically tailored to semi-arid regions like Aruba. Thorough investigations that consider local socio-economic circumstances, environmental variables, and community viewpoints are essential for accurately assessing the economic viability of RWH systems in Aruba.

Conclusion

An economic analysis of RWH systems is vital in the search for a cost-effective solution to water unreliability especially in developing countries, such as Aruba. Clear and accessible information about the economic viability is very important in the potential implementation of RWH systems, ensuring water reliability. Therefore, the research question of this paper entailed: How economically viable is the implementation of rainwater harvesting systems in Aruba? Despite the potential benefits, research on the economic viability of RWH in developing countries, especially small island developing states (SIDS), remains limited. Aruba, classified as a developing country due to its lower economic performance, confronts challenges related to high water tariffs set by Water- en Energiebedrijf Aruba (WEB) N.V., the only water and power producer on the island.

With the data gathered from a systematic literature review, a survey, and interviews, the costs and benefits associated with the RWH systems have been assessed. Factors such as initial investment, O&M costs, as well as potential benefits like reduced water bills are considered. Insights from the study include observations on the average annual income in Aruba, which exceeds the minimum wage, indicating a relatively affluent population. Despite this, the cost of water from WEB remains a significant expense for households, highlighting the potential economic benefits of RWH systems. The study also presents a cost-benefit analysis of implementing different RWH systems, examining their costs and potential returns. As shown in Table 3, totes (IBC's) have the lowest total costs in AWG per liter and a bioswale has the lowest total costs in AWG per meter. Although the majority of costs are expressed in monetary terms, some RWH systems such as check dams and agroforestry lack information on the monetary values. The operational and maintenance costs of agroforestry are measured in time, recognizing time as a valuable resource. Nevertheless, if time is not considered a cost factor, agroforestry emerges as one of the most economically viable RWH systems to implement. While data on the monetary benefits of RWH systems in Aruba are lacking, simulation results suggest that higher utilization of rainwater could enhance their economic viability over time. Furthermore, the paper assesses the volume and lifespan of the RWH systems, emphasizing on factors such as location, maintenance, and environmental conditions. The lower the payback period, the more attractive the investment becomes.

To achieve economic viability, a systems benefits must outweigh its costs, taking into account societal impacts, externalities, and environmental factors. Although project revenue serves as a foundational indicator, the true benefits to society can frequently surpass initial estimations. In addition to shedding light on the economic costs and benefits, further research and consideration of RWH as a viable solution for enhancing water security and sustainability in regions facing similar socio-economic and environmental challenges would be favorable for the implementation of RWH systems in Aruba.

References

- Abbasi, S., Vaezin, S. M. H., Samani, A. N., & Bozorg-Haddad, O. (2020). Spatial Assessing of cost-effectiveness of check-dams in controlling sediment load. University of Tehran. https://www.researchgate.net/publication/340384306_Spatial_Assessing_of_cost-effectiveness_of_check_dams_in_controlling_sediment_load_Case_study_Kond_watershed
- Abdulla, F. (2019). Rainwater harvesting in Jordan: potential water saving, optimal tank sizing and economic analysis. Urban Water Journal, 17(5), 446–456. https://doi.org/10.1080/1573062x.2019.1648530
- Amos, C. C., Rahman, A., & Gathenya, J. M. (2018). Economic analysis of rainwater harvesting systems comparing developing and developed countries: A case study of Australia and Kenya. Journal of Cleaner Production, 172, 196–207. https://doi.org/10.1016/j.jclepro.2017.10.114
- Aruba Island. (2024). Facts, maps, history, culture & more. https://www.aruba.com/us/our-island
- Austin, J. (2017). Tank Coatings and Maintenance (The SUEZ Canal Company, Ed.) [Slide show; Powerpoint]. https://www.rusa-or.org/files/4c728ec47/Concrete+%26+Steel+Tank+Maintenance.pdf
- Beaujon, R. J., & Stuivenberg, P. A. (1948). De Landswatervoorzieningsdienst. https://ia803106.us.archive.org/30/items/BNA-DIG-KOSTBARE-0165-ARUBA-05-LWV/BNA-DIG-KOSTBARE-0165-ARUBA-05-LWV.pdf
- Bowling, J., Tattersfield, S., & Darakjian, T. (2011). Triple bottom line assessment of rooftop catchment system. In UBC Social Ecological Economic Development Studies (SEEDS) Student Report. University of British Columbia. https://doi.org/10.14288/1.0108625
- Bryman, A. (2012). Social research methods. Fourth edition. Oxford University press.
- Campisano, A., Butler, D., Ward, S., Burns, M. J., Friedler, E., DeBusk, K. M., Fisher-Jeffes, L. N., Ghisi, E., Rahman, A., Furumai, H., & Han, M. J. (2017). Urban rainwater harvesting systems: Research, implementation and future perspectives. Water Research, 115, 195–209. https://doi.org/10.1016/j.watres.2017.02.056
- Cardoso, R. N. C., Blanco, C. J. C., & Duarte, J. M. (2020). Technical and financial feasibility of rainwater harvesting systems in public buildings in Amazon, Brazil. Journal of Cleaner Production, 260, 121054. https://doi.org/10.1016/j.jclepro.2020.121054
- Coelman, I. T. (2024). The efficiency and feasibility of Rainwater harvesting systems in Aruba: An assessment with multi-criteria analysis, including the preferences of the Aruban community, in Mijts, E. & Ballantyne, J. UAUCU Student Research Exchange Collected Papers 2024
- Departamento Meteorologico Aruba. (2020). Aruba climatological summary 2020. http://www.meteo.aw/files/Download/aruba_rep_2020.pdf
- Department of Economic Affairs, Commerce and Industry of Aruba. (2018). Entrepreneurs Development Policy for Aruba. In https://www.deaci.aw/wp-content/uploads/2019/09/Entrepreneurs-Policy-2018-2021.pdf. Aruba Government. https://www.deaci.aw/wpcontent/uploads/2019/09/Entrepreneurs-Policy-2018-2021.pdf
- Diaz-Maroto Knöfler, Y., Ramos, M. & Stahlberg, S. (2024). [Unpublished raw data on Rainwater Harvesting in Aruba]. Utrecht University & University of Aruba.
- Fernando, J. (2024, March 7). Net Present Value (NPV): what it means and steps to calculate it. Investopedia. https://www.investopedia.com/terms/n/npv.asp
- Gheuens, J., Nagabhatla, N., & Perera, D. (2019). Disaster-Risk, Water Security Challenges and Strategies in Small Island Developing States (SIDS). Water, 11(4), 637. https://doi.org/10.3390/w11040637
- Godsey, L. D. (2010). Economic budgeting for agroforestry practices. In AGROFORESTRY

IN ACTION. University of Missouri Center for Agroforestry. https://centerforagroforestry.org/wp-content/uploads/2021/05/af1006.pdf

- Government of Aruba. (2023, November 30). Wages & Minimum wages. https://www.gobierno.aw/en/wages-minimum-wages
- Hassanli, A. M., & Beecham, S. (2013). Criteria for optimizing check dam location and maintenance requirements (Doctoral dissertation, Nova Science). https://www.researchgate.net/profile/Ali-Hassanli/publication/287636490_Criteria_for_optimizing_check_dam_location_and_maintenance_requirements/links/56a6bb6508ae860e0253cf4c/Criteria-for-optimizing-check-dam-location-and-maintenance-requirements.pdf
- Hayes, A. (2024, February 26). What Is Cost-Benefit Analysis, How Is it Used, What Are its Pros and Cons? Investopedia. https://www.investopedia.com/terms/c/cost-benefitanalysis.asp
- Juliana, I. C., Kusuma, M. S. B., Cahyono, M. S. D., Kardhana, H., & Martokusumo, W. (2017). Rainwater Harvesting System Implementation for domestic water use: the environment and financial benefits. In Springer eBooks (pp. 411–421). https://doi.org/10.1007/978-981-287-661-4_41
- Kooyman. (n.d.). Eslon Half Round Gutter Type 150 4 m PVC Grey. https://www.kooymanbv.com/aruba_en/eslon-pvc-half-round-gutter-type-150-4-meter-length-grey100003656.html
- Mitchell, C. (2024, February 10). What is an initial investment? Smart Capital Mind. https://www.smartcapitalmind.com/what-is-an-initial-investment.htm
- Ndeketeya, A., & Dundu, M. (2019). Maximising the benefits of rainwater harvesting technology towards sustainability in urban areas of South Africa: a case study. Urban Water Journal, 16(2), 163–169. https://doi.org/10.1080/1573062x.2019.1637907
- Nel, N., Jacobs, H. E., Loubser, C., & Du Plessis, K. (2017). Supplementary household water sources to augment potable municipal supply in South Africa. Water S.A./Water SA, 43(4), 553. https://doi.org/10.4314/wsa.v43i4.03
- Osouli, A., Bloorchian, A. A., Grinter, M., Alborzi, A., Marlow, S. L., Ahiablame, L., & Zhou, J. (2017). Performance and cost perspective in selecting BMPs for linear projects. Water, 9(5), 302. https://doi.org/10.3390/w9050302
- Oxley, D., & Baete, G. (2012, September). Time is money. Principal Leadership, vol. 13, no. 1. National Association of Secondary School Principals. https://go-gale-com.proxy.library.uu.nl/ps/retrieve.do?tabID=T002&resultListType=RESULT_LIST&searchResultsType=SingleTab&retrievalId=c31e2487-8b5e-455e-b8bb-ae2a03808879&hitCount=1&searchType=AdvancedSearchForm&currentPosition=1&docId=GALE%7CA373033296&docType=Article&sort=RELEVANCE&contentSegment=ZONE-MOD1&prodId=AONE&pageNum=1&contentSet=GALE%7CA373033296&searchId=R2&userGroupName=utrecht&inPS=true
- P. Sejersen. (2016). Comparative Life Cycle Assessment of a PVC-U rain gutter system versus a system made from galvanized steel. Plastic Pipes Conference (18th ed.). TEPPFA, Berlin.
- Pal, D., Galelli, S., Tang, H., & Ran, Q. (2018). Toward improved design of check dam systems: A case study in the Loess Plateau, China. Journal of Hydrology, 559, 762–773. https://doi.org/10.1016/j.jhydrol.2018.02.051
- Patrick, S. (2005). Practical guide to polyvinyl chloride. iSmithers Rapra Publishing. (p. 3)
- Saey-Volckrick, J. (2020). What does the rebound effect tell us? Reflection on its sources and its implication for the sustainability debate. In Springer eBooks (pp. 103–118). https://doi.org/10.1007/978-3-030-42630-9_7
- Sendanayake, S. (2016). Life cycle analysis of ferro-cement rainwater tanks in Sri Lanka: A comparison with RRC and HDPE tanks. International Journal of Applied Engineering Research, 12(2), 1-8.

- Silva, C. M., Sousa, V., & Carvalho, N. V. (2015). Evaluation of rainwater harvesting in Portugal: Application to single-family residences. Resources, Conservation and Recycling, 94, 21–34. https://doi.org/10.1016/j.resconrec.2014.11.004
- The Caribbean Environmental Health Institute. (2009). Handbook on Rainwater Harvesting for the Caribbean: A practical guideline featuring best practices for rainwater harvesting in small island Caribbean. United Nations Environment Programme and the Caribbean Environmental Health Institute. https://www.pseau.org/outils/ouvrages/cehi_handbook_for_rainwater_harvesting_for_the_caribbean_2009.pdf
- UnitConverters. (2024). Convert cubic millimeter to liter. https://www.unitconverters.net/volume/cubic-millimeter-to-liter.htm
- WEB Aruba N.V. | Water- en Energiebedrijf Aruba N.V. (2024a). Calculate your water bill. https://webaruba.com/your-water-bill/calculate-your-water-bill
- WEB Aruba N.V. | Water- en Energiebedrijf Aruba N.V. (2024b). Technologies used. https://webaruba.com/water-production/technologies-used
- WorldData. (2024, March). Aruba: country data and statistics. https://www.worlddata.info/america/aruba/index.php#:~:text=According%20to%20the%20definition%20from%20the%20International%20Monetary,USD%20Aruba%20is%20one%20of%20the%20high-income%20countries.
- Wright, K., Koo, J., & Beldy, A. (2015). Enhancing Resilience in Boston: A Guide for Large Buildings and Institutions. A Better City. https://www.abettercity.org/docs/resiliency%20report%20web%20FINAL.pdf
- Zhaldak, H., & Somova, Y. V. (2023). Analyzing the market structures and the importance of monopolies in the economic development. BìZnes ÌNform/Bìznes Ìnform, 4(543), 6–14. https://doi.org/10.32983/2222-4459-2023-4-6-14

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Amazing to escape the cold Dutch winter!

Aruba.

An island that I had never heard of before (please don´t be mad) until the opportunity of coming here showed up. I love to travel and have been fortunate enough to visit a few places. Sadly, the time was always only very limited and max 3 weeks. This time, it was 2,5 months, WHAT A DREAM. The words that I am writing down do not even get close to all the pictures and memories I got to experience here. People always say one picture says more than a thousand words, well one memory is indescribable, let alone 2,5 months full of memories.

I was blessed to be able to come with a very good friend of mine (Marta) to this island. This made the anticipation very exciting and this whole trip already a success for me. But what came up during this time was not something I was expecting. Yes, Aruba is a beautiful island with incredible nature and great weather (amazing to escape the cold Dutch winter!), but my personal highlight was to meet new people, experience Aruban culture and have the time to understand and live the Aruban island life.

When we arrived here, we got the chance to experience Carnival which was a lot of fun! Then, I got to meet and have class with amazing people who inspire me a lot. I also began to learn the language, Papiamento, and it was a fun challenge that I shared with my peer friends. Another highlight of mine was swimming with the turtles. I did not think I would be able to experience this so soon! I was always amazed by tropical ecosystems, especially coral reefs, and I got to see them and share the experience with my new friends here which made it very special. When meeting new people, I love to play sports as it is an easy way to involve more people. As I play volleyball in the Netherlands, I wanted to continue playing in Aruba and I met a very nice group here that plays regularly on the weekends. They even introduced me to a new sport: beach tennis. I enjoyed it a lot and even participated in tournaments which I did not expect. I was just a beginner, but it was a lot of fun! Seeing the support that we gave one another even though we barely knew each other was truly surprising in a positive way, making me feel less like I was living 8000km away from my family and friends.

The people I met and Aruba itself already have a special place in my heart that I will never forget. I am forever grateful to have had this experience and share the memories with my friends. Exchanges are said to be great but there is no way I can put my feelings into these few words.

Masha danki Aruba!

An exploratory paper: Societal gaps for a transformation towards sustainable rainwater harvesting in Aruba.

Yanina Diaz-Maroto Knöfler

Aruba is a small island state in the Caribbean with unique climatic conditions and landscapes. It is part of the Kingdom of the Netherlands but since the 1980s it has been an autonomous state within the Kingdom (Derix, 2016). Being a small island, it has unique characteristics where water has consistently been a limited resource.

Water has always been present on the island, with rainwater harvesting used as an ancient method to collect fresh water. The early inhabitants, mainly the Arawak natives, gathered their water supply through surface water and groundwater wells (Marchena & Halman, 2018). Later, cisterns were incorporated into the houses to harvest rainwater from roofs. In the 20th century, the desalination plant was introduced with thermal desalination technology and, later, the reverse osmosis membrane technology. This occurred due to the transition of the national economy from gold and aloe to oil refining (Derix, 2016). With the oil refinery industry expanding, the water demand increased, and a new, additional, freshwater source was needed leading to the desalination plant. This led to a boost of economic and societal development of the island. Several industries, among others the tourism sector, were able to grow and expand due to a reliable (freshwater) drinking supply (Marchena & Halman, 2018). In the 1960s, a law was passed that forbade the construction of rainwater harvesting tanks in new buildings. During this time, many new houses were built due to population growth, but without the tanks (Interview results I1, explanation in methods). In 2008, the law was changed again, allowing the addition of rainwater harvesting (RWH) tanks to buildings. Nevertheless, the news of implementing these laws has not yet reached the entire Aruban community. This represents the Precontemplation stage of the Stages of Behaviour change model by Prochaska et al. (1992). The Precontemplation stage represents the human unawareness of a problem. The following stages Contemplation, Preparation, Action, and Maintenance illustrate a person's phase of a desired behaviour towards acting and continuing to act on the problem.

This is one example that brings the RWH implementations in Aruba into context. Today, several challenges require us to rethink practices and approaches. The desalination plant contributed to boosting Aruba's economy and society by providing water supply to the entire island, but it also caused some environmental challenges (Marchena & Halman, 2018). The process of removing the salt from the seawater to gain drinking water is very energy-intensive. Furthermore, in Aruba, the energy source is mainly HFO (heavy fuel oil), more concretely, fossil fuels that have negative environmental consequences through their extraction and use, like habitat destruction and high greenhouse gas emissions. Moreover, the production of drinking water generates wastewater (brine) that is released back into the seawater unfiltered and impacts the nearby ecosystems, e.g. coral reefs (Marchena & Halman, 2018).

The brine contains substances that could potentially be removed for different uses and circular purposes that can help mitigate environmental effects, also called resource recovery (Acevedo et al., 2023).

Thus, there is potential for improvement towards a sustainable water supply. The addition of rainwater harvesting could increase Aruba´s water security and -resilience. The high dependency of the island on the desalination plant could be catastrophic in the case of e.g. an accident or a natural disaster. The island has an emergency supply of (drinking) water for the population but a more diverse, second supply source could prolong the number of days of water security. Regarding sustainability, the trend is expanding as more and more nations, companies and individuals want to contribute to sustainability. Aruba has committed to, nationally, implementing the Sustainable Development Goals (SDGs) in the next decade (Overheid van Aruba, 2024). Therefore, how can a small island state contribute globally and locally to society and become more sustainable?

Due to the small size of the island, the achievement of a global change is not realistic. However, since islands have hard boundaries, small size, isolation, recent human settlement and many similar features, they are often described as models that show exemplary development or characters (Warren et al., 2015). They can serve as an example to follow or replicate in other places around the globe. Local-scale actions in island contexts can have large impacts that appear quicker as a result of the small, isolated ecosystems in which they exist. In the context of water and the sustainability of an island, it is important to not only look at the direct issues but at the system as a whole. One should approach these issues as so-called wicked problems, problems that don't have one single solution as the system is very complex, having different interconnections. Islands have strong interlinkages (Warren et al., 2015), as a result, it is required to look at island challenges from multiple perspectives and disciplines. So, interdisciplinary and transdisciplinary perspectives need to be included for a complete transition towards sustainability, including rainwater harvesting in Aruba. For the development of understanding sustainable water supply, the following perspectives will be included in this study: environment, socio-economic, politics and interdisciplinarity.

Hence, the question arises what gaps there are in the societal system of Aruba that need to be addressed to solve the issue at hand. The question that this paper focuses on is **"What societal gaps can be identified in Aruba for a transformation toward sustainable rainwater harvesting?"**

For a deeper understanding, several key concepts need to be clarified: First, rainwater harvesting in this paper is used as the practice of collecting rainwater with e.g. rainwater tanks or rain gutters. This water is then re-used for non-potable purposes, for instance, irrigation in agriculture. Second, a gap is defined as a "lack that means something is not complete" (Cambridge Business English Dictionary). Societal gaps can be knowledge gaps, communication gaps or others that are primarily connected to society but also influence other environmental fields or individual action. This paper will explore the societal gaps in Aruba that might hinder the implementation of RWH systems.

Methods

I conducted a literature review and linked the outcomes of this review with the findings of an ongoing research and consultancy project on the feasibility of rainwater harvesting in Aruba. A literature search demonstrated a limited availability of academic publications on rainwater harvesting and related issues. Yet, the articles that were found have been integrated into this paper. Simultaneously, data was collected through interviews and surveys on RWH knowledge, practices and opinions among stakeholders in the Aruban community. Seven interviews were conducted with people from different fields. In this paper the interviews will be cited with numbers one to seven (i.e. "I1", "I2", "I3", "I4", "I5", "I6", "I7"). These include a consultant, a representative of DOW (Department of Public Works), a citizen, a representative from the farmer community, two hotels in Aruba, and a representative of DNM (Directorate of Nature & Environment). The limited time in which the project was executed did not allow for more interviews with stakeholders from different backgrounds. Still, through the semi-structured interviews that were conducted, a deeper understanding of the environmental, socio-economic, and political factors that influence RWH implementation was gained. Next to the interviews, a survey was sent out to reach a general public, i.e. a broad audience. It gave a general idea about the knowledge the people have about RWH and whether they practice it. This survey received 102 answers and will be cited with "survey" in this paper.

Societal gaps

Environmental gaps

One of the benefits of rainwater harvesting includes the reduction of erosion and flooding through decreasing surface runoff (van Houselt, 2021). In Aruba, there are no flood mitigation plans (I2). Hence, in the event of rain, the streets get flooded and transport large amounts of sediment that damage other ecosystems on and around the island. Next to the sediments that flow into the sea, pollution reaches the sea as well, which leads to negative impacts on marine life (Lyubimova et al., 2016). As rainwater harvesting lowers these impacts, it could be a solution that contributes to flood prevention. 98% of the respondents to the survey believe that flood management should be improved (survey, 2024). Yet, there is no data on the awareness of citizens about rainwater harvesting preventing floods. Another observation made during the consultancy project is that the community partly uses rainwater for irrigation purposes. This is considered to be better as it leads to a stronger growth of the plants (I1, I3). Rainwater contains diverse minerals while the water from the desalination process is pure and only gets enriched with a few selected minerals. However, this knowledge is not widespread (survey, 2024). In addition to these results, one main reason why the community in Aruba does not implement RWH is that they believe it does not rain enough, especially in the dry season. 13% say the lack of rain is a barrier to the application (survey, 2024). However, in Aruba more than 7 times of the drinking water production falls in the form of rainwater per year (on average it rains 450-480mm/yr on the island and the island is 175km2, leading to 85-90 million m3/yr rainfall on the island while the water production of WEB is 12 million m3/yr leading to around 7x more rainwater than drinking water production; Eric Mijts, personal communication, 2024). This is not widely known though either. As Aruba has a wet and dry season it is believed that the dry season interferes with the abundance of rainwater falling during the year (survey, 2024). Interviewee 1 shared that, from personal experience, it is possible to water all their plants with an adequate rainwater collection system. Thus, with the right infrastructure, materials and funds, this could be a feasible practice. Finally, looking at the current water production in Aruba, most of it is produced with the use of HFO (heavy fuel oil). Next to the negative environmental impacts that importing and burning HFO has, the process of extracting it leads to, among others, land change, waste and noise on-site (Ngene et al., 2016). The reverse osmosis technology emits around 0.08–4.3 kgCO2/m3 and uses 4.0–4.5 kWh/m3 of energy during water production (Cornejo et al., 2014). In addition, the production process also produces wastewater, called brine water, that is often released unfiltered into the environment which damages surrounding ecosystems. Nevertheless, 52.5% of the Aruban population believe that the desalination plant is environmentally friendly (survey, 2024).

Socio-economic gaps

The main societal gap that was identified is the need for more awareness and the availability of accurate information. The Aruban population is not informed enough about the possibilities and technical ways to implement rainwater harvesting systems. As Mukarram et al. (2023) describe, financial insolvency, lack of technical skills, and insufficient education are the main reasons for the unsuccessful implementation of rainwater collection. 51% of the respondents to the survey (2024) indicated that they cannot afford to install RWH systems in their household. Other sources, like Peters (2016), confirm that the absence of socio-economic factors in RWH projects was the most significant motive to why it was not successful. Van Househelt (2021) describes that in Curacao the application of rainwater collection was not economically feasible. In addition, several people expressed that they do not have the knowledge and skills to build and maintain the systems (survey, 2024) which is in line with the statements of the above-mentioned sources. Still, a benefit that many Arubans discovered is that rainwater harvesting reduces their water bills. 71.6% say that their water bill is too high (survey, 2024). The water production involves many different stages and, therefore, is expensive. RWH could contribute to supporting the community financially. Moreover, there are many large buildings where the roofs could be used to collect rainwater but the lack of initiative by private owners and the government makes the practice currently uncommon for the island population (I2, I6).

Political

Rainwater harvesting currently takes place in Aruba but not on a large scale. Only a small number of individual households are implementing it. As mentioned before, a law was introduced in the 1960s prohibiting new rainwater harvesting infrastructure; and then changed again towards allowing new RWH systems some 50 years later (I1). The interviews demonstrated that there is unclarity in the Aruban population about whether it is allowed to harvest rainwater or not (I2, I3, I7). While interviewee 2 shared the certainty that rainwater harvesting is allowed, interviewee 7 claimed that it was not allowed. In addition, the ambiguous information that is shared on this topic creates distrust in the government (I1, I3, I4). Distrust can also appear when a citizen's evaluation of a political situation, and the competencies of the actors in a government, do not align with the expected results (Bertsou, 2019). As a result, the citizens do not rely on the government to act, or to support them. Moreover, the data from the consultancy project indicated that according to most interviewees, there is no water quality measurement, e.g. mineral, toxicity, pH, or conductivity, and management for the (collected) rainwater (I1, I2, I3, I4). Nevertheless, the interview with DNM demonstrated that there are measurements taken at several dams, the natural rainwater harvesting systems in Aruba, but these are neither complete nor timely accessible (I7). Thus, citizens of Aruba are not sure what they can use the water for, which makes them hesitant about the purpose and safety of collecting rainwater. Finally, the diverse interests of different stakeholders like the government, desalination plant or the tourism industry could affect the contribution and action to and process of the implementation of rainwater harvesting (I1, I2, I3, I4). Depending on the distribution of power between these interests, it could benefit or hinder the process of implementing rainwater harvesting systems. From the survey, 86% of the participants wish the government to initiate support for RWH in households. This could be in the form of policies, financial support, or other forms of incentives.

Interdisciplinarity

The data of the consultancy project revealed that communication between governmental departments is not high (I2). As a result, the cooperation and efficiency for interdisciplinary projects like rainwater harvesting are low. A different approach, that is applied in different places around the world like Asia and Africa, is community-based rainwater harvesting (CBRWH). According to Kim et al. (2016), the community-based approach can significantly improve the water supply system. This would require cooperation between several stakeholders but could have a great impact on the Aruban community. CBRWH could be implemented by using several larger locations for rainwater harvesting that then would be distributed to the individual households close by. This source also states that there is a need for local pilot projects for more research and successful models. This would shed light on the significant technical and societal success factors for CBRWH. Aruba, being an isolated island, could become an exemplary model on how RWH could be implemented and benefit the whole community, as mentioned by Warren et al. (2016).

Conclusion

Coming back to the guiding question **"What societal gaps can be identified in Aruba for a transformation toward sustainable rainwater harvesting?"**, this paper examined the gaps from different dimensions, including the environmental, socio-economic, political and interdisciplinary. The first gap that was identified is the knowledge and educational gap. The Aruban population is not aware of the possibilities, opportunities and barriers that come along with rainwater harvesting. There is a lack of easy access to information about the types of RWH, the costs and maintenance. The results indicate that the Aruban community wants to get involved and wants to act environmentally friendly but that missing and incomplete information on these topics is one of the main barriers to act. Data about the quality of the collected rainwater is either non-existent or difficult to access. Thus, citizens are not sure what they can use it for and if it is clean or not. In addition, one of the largest, unexpected findings is the misconception of the existing and past laws. Different beliefs regarding the authorization of rainwater harvesting systems have been found during the data collection. There are also no noticeable governmental or other efforts to inform the community on this. Another gap that has been observed is the financial gap. Even though many citizens are interested in implementing rainwater harvesting systems, according to the survey, they are not able to afford it. Currently, there is no active financial support from the government for the development of RWH infrastructures at a household level. Hence, the infrastructure for rainwater harvesting is limited. The final gap that has been classified in this paper is the communication gap. The communication between the governmental departments, the government and citizens as well as between citizens is limited and can be related to the distrust of the government and an unwillingness of the citizens to help each other out.

These gaps overlap in different disciplines and need to be addressed. The implementation of rainwater harvesting depends on the tackling of these barriers. This could be started by looking at possible ways to increase awareness, leading to guiding the citizens from the Precontemplation stage to the Contemplation stage, which represents the phase of unawareness to awareness of a problem (Prochaska et al., 1992). It is then recommended to research specific intervention techniques, for this case study, to direct citizens towards a more active behaviour that implements rainwater harvesting. Furthermore, it is advised to investigate the most optimal ways of RWH on the island, not to promote rainwater harvesting as the only and needed solution, but rather as a complementary way to achieve a more sustainable water supply.

References:

- Acevedo, D., Mijts, E., John, N., El Bouzidi, M., & van Der Bruggen, B. (2023). Perspective in resource recovery from reverse osmosis brines: the case for sustainable seawater refineries for small islands. *Journal of Chemical Technology & Biotechnology, 98*(10), 2359-2364.
- Bertsou, E. (2019). Rethinking political distrust. *European Political Science Review, 11*(2), 213-230.
- Cambridge Business English Dictionary. Gap. *In Cambridge Dictionary.* https://dictionary.cambridge.org/us/dictionary/english/gap
- Cornejo, P. K., Santana, M. V., Hokanson, D. R., Mihelcic, J. R., & Zhang, Q. (2014). Carbon footprint of water reuse and desalination: a review of greenhouse gas emissions and estimation tools. Journal of Water Reuse and Desalination, 4(4), 238-252.
- Derix, R. W. M. (2016). The history of resource exploitation in Aruba. Central Bureau of Statistics. https://www.cbs.aw/wp/wp-content/uploads/2016/12/H2_LandscapeSeries_The_History_Of_Resource_Exploitation_In_Aruba_10-10-2016.pdf
- Eric Mijts, personal communication, 2024
- Kim, Y., Han, M., Kabubi, J., Sohn, H. G., & Nguyen, D. C. (2016). Community-based rainwater harvesting (CB-RWH) to supply drinking water in developing countries: lessons learned from case studies in Africa and Asia. Water science and Technology: water supply, 16(4), 1110-1121.
- Marchena, F. A., & Halman, J. I. (2018). Aruba's desalination's knowledge and experience: conquering the sea toward desalination's sustainability.
- Mukarram, M. M. T., Kafy, A. A., Mukarram, M. M. T., Rukiya, Q. U., Almulhim, A. I., Das, A., ... & Chowdhury, M. A. (2023). Perception of coastal citizens on the prospect of community-based rainwater harvesting system for sustainable water resource management. Resources, Conservation and Recycling, 198, 107196.
- Ngene, S., Tota-Maharaj, K., Eke, P., & Hills, C. (2016). Environmental and economic impacts of crude oil and natural gas production in developing countries. *International Journal of Economy, Energy and Environment, 1*(3), 64-73.
- Overheid van Aruba. (2024, January 20). Capacity building for the implementation of the sustainable SDGs in Aruba. *Overheid van Aruba.* https://www.gobierno.aw/nl/capacity-building-for-the-implementation-of-the-sustainable-sdgs-in-aruba
- Peters, E. J. (2016). Success and success factors of domestic rainwater harvesting projects in the Caribbean. Journal of Sustainable Development, 9(5), 55. https://doi.org/10.5539/jsd.v9n5p55
- Prochaska, J. O., DiClemente, C. C., & Norcross, J. C. (1992). In search of the structure of change. In *Self Change: Social psychological and clinical perspectives* (pp. 87-114). New York, NY: Springer New York.
- van Houselt, G. J. (2021). A Rainwater Harvesting System based Blueprint for Excess Runoff Management on Caribbean Small Island Developing States Investigating the Feasibility of the Rigofill System Combined with New Dam Structures in the Coral Estate Resort–Curacao (Master's thesis).
- Warren, B. H., Simberloff, D., Ricklefs, R. E., Aguilée, R., Condamine, F. L., Gravel, D., ... & Thébaud, C. (2015). Islands as model systems in ecology and evolution: Prospects fifty years after MacArthur-Wilson. Ecology Letters, 18(2), 200-217.

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‘How can you be cold? You’re from Finland’.

‘How can you be cold? You’re from Finland’ is something I’ve gotten relatively used to hearing after moving abroad and expressing any signs of coldness to people. Therefore, moving to a place where being cold is as far away as it gets was a perfect solution to get away from the rainy, grey Dutch winter, as well as the comments on how a Finnish person can never be cold.
I first heard of the possibilities of doing the mandatory Consultancy project in Aruba through a casual instagram post from the group before me, showing the vibrant carnival vibes and beaches with the caption “skip the winterdip”. This got me hooked, because who would not want to be a part of the only group of your programme that gets the possibility of doing a fascinating consultancy project in Aruba instead of the Netherlands in the winter months?

One of the most important things I will take with me from my experience in Aruba is the overwhelming **kindness**. Coming from a culture where you help your neighbour only when you have to, and share things only to ask for reciprocation has made me appreciate the Aruban culture of being there for each other with no expectation of anything in return, familiar or not. The form of kindness we experienced ranged from strangers offering us snacks and drinks at the carnival parade in the first week, Nathalie from Santa Rosa technically adopting us as her extra daughters, to our Aruban classmates being the only ones cheering us on after having walked 40 km across the island for the whole day.

In terms of research, this project has been eye-opening. On various occasions, all of us have expressed this project as being one of the first moments we realised that our expertise is being used in a real world environment. I initially thought people were going to look at us thinking ‘ugh those students again doing their research’. But I couldn’t have been more mistaken. People were more than willing to meet and discuss the topic of our research and our Aruban friends even translated our whole survey into Papiamento without question. Finally, I want to say that although the consultancy project has been hours of hard work, being able to do it in Aruba surrounded with amazing people made the whole thing feel like a vacation.

Environmental challenges and facilitators for rainwater harvesting in Aruba.

Sara Ståhlberg

1. Introduction

The effective implementation of rainwater harvesting (RWH) systems on an island like Aruba relies heavily on the consideration of various factors and their consecutive facilitators and challenges. One of these factors is the climate and environment on the island. Aruba is characterized by its semi-arid hot climate, with average temperatures around 28 °C and average winds of 7,4 m/s from the northeast direction (1991-2020) (Departamento Meteorologico Aruba, n.d.). The precipitation on the island ranges from periods with little to no rainfall to periods of torrential rainfall. Aruba's consistently warm climate and long periods of little rainfall combined with its natural attributes have led to the island being one of the most tourist-intense and population-dense regions in the Caribbean (Jurgens et al., 2024). Due to the overpopulation of the island bringing about large pressures on nature in combination with climate change, the environment becomes an increasingly more important aspect to consider for future sustainable solutions, including rainwater harvesting.

Throughout history, rainwater has been a key resource for daily survival in Aruba. A hydrogeochemical study on the quality of groundwater of Aruba determined that the groundwater on the island, due to seawater intrusion, sea spray and evapotranspiration varies from fresh to relatively brackish (Van Sambeek et al., 2000). Hence, the water obtained from groundwater sources often does not meet the standards for potable uses, such as drinking water (Van Sambeek et al., 2000). Additionally, the rock substrate of the island often impedes the infiltration of water to form groundwater reserves (Derix, 2016b). Therefore, especially in the past, the population of Aruba has taken advantage of the copious amounts of rain falling occasionally on the island through the construction of *'rooien'* (dry riverbeds) and *'tankis'* (rainwater dams), to allow for the collection and utilization of the water (Derix, 2016b; Haviser & Hofman, 2015). These are still actively used on the island, and many farmers use the water from the *tankis* for irrigation purposes.

Another environmental phenomenon related to rainfall in Aruba is flooding caused by torrential rainfall. Due to the large volume of rainwater that falls at once, certain areas and neighborhoods on the island are regularly faced with the consequences of flooding. This can include erosion, damage to properties, possible accidents, and traffic jams (Derix, 2016d). According to Derix (2016d), the main cause of flooding seems to be new construction causing a change in the landscape and the natural flow of water. This is often related to the blocking of the *'rooien'*.

Although the *rooien* and *tankis* do a decent job in redirecting the large volumes of rainfall on the island, the rainwater still causes some negative environmental effects. The rainfalls are heavy and short, meaning that runoff is strong, which causes erosion of the topsoil in large parts of the island (Derix, 2016b). This loosened sediment then often ends up in the sea, which additionally has various effects on the marine environment (Fabricius, 2005). Hence, a functioning and collaborating urban and natural water system, with the help of RWH to direct the water away from densely populated areas, the collection of it in natural areas and the utilization of the collected water for non-potable purposes could benefit not only the population with another water supply, but also mitigate the negative environmental effects caused by heavy rains on the island. Additionally, according to Hofman & Paalman (2014), "Studies have shown that application of RWH results in a reduction of stormwater runoff volume between 20 to 50%".

This paper will explore the environmental challenges and facilitators when considering broader RWH implementation in Aruba. To achieve this, the following research question has been developed: *How does the identification of climatic and environmental conditions affect possible RWH system implementation?* The paper is structured as follows. First, the methodology of the research is presented. Second, the conceptual framework is laid out, offering a thorough overview of the concepts, the study area as well as the research gap that the research aims to explore. Next, the results are presented in tables and a figure. Last, the results will be explored through a discussion, followed by a conclusion.

2. Methodology

This paper is based on the research for a Consultancy Project investigating the feasibility of RWH system implementation on a national scale in Aruba. The consultancy research has been divided into three different dimensions, namely environmental, socio-economic, and political. A large amount of data has been collected to investigate all three dimensions, and the research methods include interviews, a survey and literature reviews. For this paper, these methods have been adopted too, focusing on the data relating to the environmental factors of the research.

Firstly, a literature review has been done to investigate the possible environmental conditions and phenomena that could affect RWH in Aruba. For this, the search engines Google Scholar and WorldCat have been utilized. Next, semi-structured interviews were conducted with five stakeholders. These stakeholders included DOW (Department of Public Works), a citizen, a farmer's organization, the sustainability manager at a hotel as well as DNM (Directorate of Nature and Environment). The interviews gave an insight into the thoughts and knowledge of the interviewees on water usage, water management and RWH in Aruba as well as general opinions on factors that affect RWH implementation. The interviews were transcribed and coded in NVIVO into categories related to the dimensions of the consultancy research. Examples of interview questions for the environmental dimension are as follows:

- *What is the current flood management infrastructure on the island, and do you think RWH systems implementation can contribute to flood risk management and reduction?*
- *What do you think of people taking water from the dams? Is this beneficial or does it bring disadvantages?*

Lastly, a survey was sent out to the Aruban community, in which people could express their opinions and knowledge on their water usage, RWH, and water management on the island. For this, both closed and open questions were used, in addition to 11 Likert scale statements. A Likert scale is a 5 or 7 point scale used to measure the agreement of respondents, allowing them to also choose a neutral, somewhat disagreeing or agreeing answer (Batterton, 2017). After the collection of responses, the data was added into Excel and analyzed using various graphs and tables.

3. Conceptual framework

In this section, the environmental factors related to the implementation of RWH are explored. By exploring these factors in depth, a foundation of understanding of the possibilities and challenges Aruba is facing with regards to RWH can be obtained. One important note is that RWH systems do not only include for instance man-made rain gutters and cisterns, but also natural structures such as riverbeds, rainwater dams and even vegetation.

3.1. Rainfall on the island

Most of the rain in Aruba falls in the so-called 'rainy season' with a peak in November and December, and for the rest of the year, occasional rainy days occur. As opposed to other regions of the Caribbean, Aruba does not have two distinct rain seasons (Derix, 2016b). However, when it does rain, the rain is heavy and abundant, with monthly averages around 80mm for the rainy periods, while in the dry season, rainfall may be under 10 mm per month (Departamento Meteorologico Aruba, n.d.). Using these statistics, one can calculate that the volume of water that falls during one month in the rainy season could provide the whole population of Aruba with water for 29 months, considering the average monthly use of water per capita on the island is 5m3 (WEB Aruba N.V., 2024).

Considering the above, this means that the rainfall in Aruba would, volume-wise, be able to replace Aruba's whole water supply. However, to utilize rainwater, the island needs not only rain collection systems, but storage tanks that allow for the storage of enormous amounts of water for the drier periods. Additionally, it is important to note that rainwater is mainly suitable for non-potable purposes, due to possible contamination (Reijtenbagh, 2010).

Rainwater is chemically different when compared to tap water. Rainwater does not contain any added chemicals or minerals, often includes nitrates, and has a high oxygen content (Smart Water, 2024). This means that plants often grow taller when using rainwater as opposed to water from the tap, since they get the necessary nutrients to grow (Limjuco et al., 2016).

Additionally, due to the short, heavy rains, the environment of Aruba faces a problem, namely high rates of runoff and erosion. According to Derix (2016b), "the runoff is strong and the effect of erosion of top soils severe. […] heavy rains amass into large brownish runoff streams that carry topsoil and sediments towards the sea." This shows that the rainfall on the island can cause harm to the natural environment. In response, dry riverbeds *(rooien)* have been formed along the island, through which water is transported. Additionally, man-made *rooien* have been created to allow for the collection of water in various rainwater dams *(tankis)* on the island. (Haviser & Hofman, 2015).

3.2 *Rooien* and *Tankis*

The *rooien* and *tankis* on the island act as natural water retention systems to allow for the utilization of rain on the island. During the ceramic age settlements, they provided the population with water for drinking, irrigation and even travel and communication (Haviser & Hofman, 2015). These structures still work as rainwater collection systems on the island today and are mainly used by farmers for irrigation, as well as to provide water for e.g. making cement in the construction of buildings (DNM, personal communication, April 2, 2024). In addition to this, the *rooien* and *tankis* allow for a redirection of the abundant rainfall, lowering flooding on the island.

The quality of the water of nine[1] of the *tankis* on the island is monitored monthly by DNM in terms of dissolved oxygen, oxidation-reduction potential (ORP), pH, electrical conductivity, total dissolved solids, salinity, and turbidity (R. Kock, personal communication, March 25, 2024). These quality measurements are, however, not publicly available, and although quality measurements are carried out monthly, there is not a regulation framework on how much water can be extracted from the dams (DOW, personal communication, March 22, 2024).

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[1] Rooi Bosal, Cas Ariba, Pali Bonchi, Hooiberg, Rooi afo, Bushiribana, Madushi, Tanki flip and Tanki Leendert. (N. Da Silva, personal communication, March 26, 2024)

3.3 Evapotranspiration

Many small island states, including Aruba, are located close to the equator and experience high losses of surface water through evapotranspiration (Van Houselt, 2021). Evapotranspiration is a combined term for the evaporation of water to vapor from a surface area or the soil, and transpiration which is the loss of water from a plant surface, mainly through their leaves (*Oxford Reference,* n.d.). Evapotranspiration can act as an environmental challenge for e.g.farmers that rely on the dams as their water supply, as high rates of evaporation causes the dams to quickly dry out. Additionally, high rates of evaporation in combination with extraction rates hinders the infiltration of water into the soil, further causing an insufficient recharge of groundwater, leading to possible water stress (Van Houselt, 2021). Evaporation is also a phenomenon that, naturally, could become a problem in the storage of water. Unless storage tanks are closed off, there will be some degree of water loss.

In addition to the challenges of evaporation, high rates of transpiration can have a positive contribution to flood risk management. Plants can take up large amounts of water during rain periods, releasing the water into the environment through transpiration (Ferreira et al., 2021). Redirecting rainwater to areas of abundant vegetation or gardens could not only help the growth of the vegetation but also decrease the accumulation of water in various locations during times of heavy rainfall.

3.4 Land use and flood management

There are a few aspects about the land use of Aruba regarding rainfall and water management that needs exploration. Firstly, the current infrastructure on the island, particularly in urban areas, often does not account for rainwater management, especially in terms of flood management (DOW, personal communication, March 22, 2024). In general, the development of urban areas frequently results in impermeable infrastructure such as pavements and concrete structures like houses and fences. This infrastructure can lead to faster runoff, a loss of infiltration, accumulation of rainwater and even flooding (Fletcher et al., 2013). As mentioned by Derix (2016d), “Unrestrained urban planning and house construction have an impact on the natural course of the rainwater, which comes with unpredictable costs during periods of heavy rainfall”. The lack of infrastructure to account for flooding thus leads to the accumulation of rainwater in the streets in Aruba, causing various inconveniences.

Secondly, in the 1960s, a regulation was set that prohibited the construction of rainwater collecting cisterns, also known as ‘regenbakken’, in new houses (DNM, personal communication, April 2, 2024). This regulation was only lifted in 2008, and due to the large population increase on the island, a lot of houses were constructed in that period (Derix, 2016c). As a consequence, many houses on the island were built without consideration for rainwater management. Hence, the lack of both household level and island-wide water management systems in combination with the large quantities of rainfall is not only destructive to properties, but also has adverse effects on the surrounding nature (Horn, 2017).

3.5 Climate change

Another environmental aspect that needs to be considered while exploring the possibilities for RWH is how it could help mitigate climate change. Climate change is defined by the UNFCCC[2] as being "a change of climate which is attributed directly or indirectly to human activity [...]" (UNFCCC, 2005). Small island states, although being among the least contributing to climate change, are likely to suffer most from the negative effects of it (UNFCCC, 2005).

Aruba relies heavily on fossil fuels for energy- and water production, and most of Aruba's emissions originate from fossil- and liquid fuel consumption (Peterson et al., 2021). The local government in Aruba and Utilities Aruba N.V.[3] both endorse the 17 sustainable development goals (SDGs), of which one of the missions is to reduce emissions (Croes, 2022). The desalination plant in Aruba, managed by WEB, provides the island with fresh water; however, this process is highly energy-dependent, and currently 80% of the energy production in Aruba is based on fossil fuels (Croes, 2022). The use of fossil fuels leads to CO^2 emissions, which in turn plays a significant role in the acceleration of climate change (Soeder, 2020). Therefore, lowering the use of fossil fuels in the production of potable water in Aruba by generally lowering the water demand from WEB could consequently lower the CO2 emissions, mitigating climate change.

4. Findings

4.1 Survey

A total of 101 replies were obtained from the survey sent out to the Aruban community. The relatively high response rate allowed for a clear overview on the opinions of the general public on the topic. The gender of the respondents were 44,6% male and 54,5% female, 96% of them having lived in Aruba for more than five years. Some examples of the occupations of the respondents include: teacher, consultant, airline pilot, bookkeeper, beekeeper, psychologist, and shop owner. Thus, the survey has reached a large range of respondents in numerous sectors on the island. For this paper, the three most relevant Likert scale statements from the survey have been included, and the responses have been displayed in Table 1 and Figure 1.

Out of the 101 respondents of the survey, every respondent agreed or somewhat agreed on having noticed the flooding on the island after it rains, and the majority of the respondents find that flooding causes them some type of problems. In Figure 1, this is visualized by showing agreeing answers on the left and disagreeing answers on the right. Furthermore, 98% of the respondents either agree or somewhat agree that the flood management on the island should be improved.

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[2] United Nations Framework Convention on Climate Change

[3] holding company for Water en Energiebedrijf Aruba N.V. (WEB) & N.V. Electriciteit-Maatschappij Aruba (NV Elmar)

Table 1. Responses for three likert statements of the conducted survey.

	I have noticed that the streets get flooded when it rains	*The flooding of the streets when it rains is a problem for me*	*I believe that the flood management in Aruba should be improved*
Agree	84	41	83
Somewhat agree	17	38	16
No opinion	0	6	1
Somewhat disagree	0	5	0
Disagree	0	11	1
Respondents	**101**	**101**	**101**

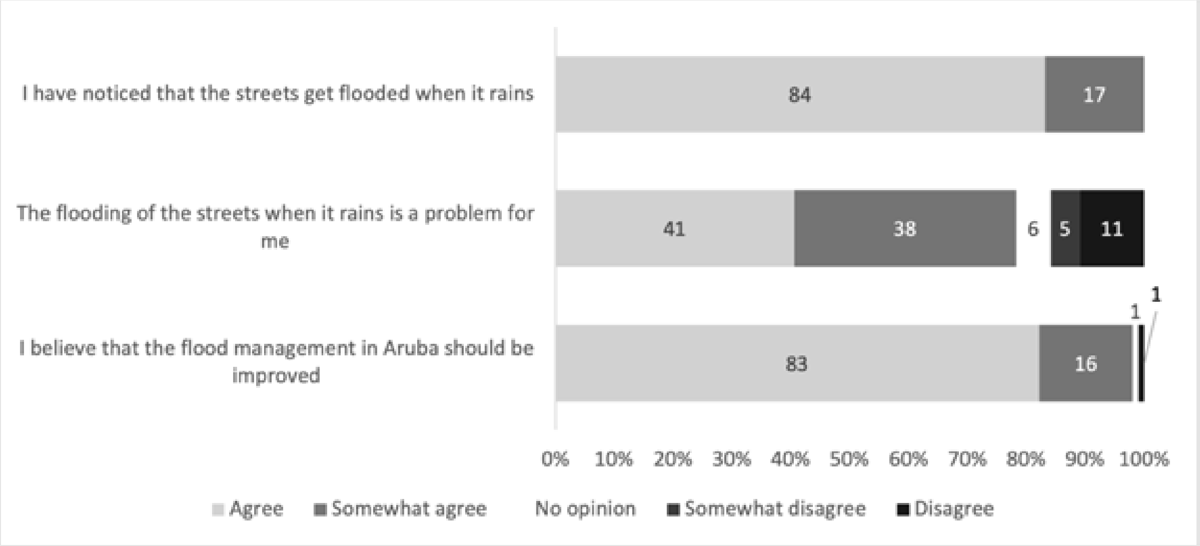

Figure 1. Stacked bar chart showing the responses for three statements of the survey. The x-axis shows the proportion of respondents in percentages, while the numbers on the bars reflect on the number of respondents for the specific answer.

Table 2. Water reuse responses from the survey

Do you reuse any water?	
Rainwater	9
Washing machine / dishwasher / shower water	15
Sewage water	13
AC water	20
No	29
Total respondents	86

4.2 Interviews

In total, seven semi-structured interviews have been conducted to obtain information for the consultancy project. Five of the interviews include information related to the environmental factors that affect RWH in Aruba. Due to anonymity, the interviewees have been named I1 (DOW), I2 (a citizen), I3 (farmer's association), I4 (hotel industry worker) and I5 (DNM). The key themes of the interviews are as follows:

- Rainwater quality and plants
- Functionality of *rooien* and *tankis*
- Water retention

The respondents expressed rainwater as being better for the plants, due to its higher mineral content, leading to faster growth and better color of the plants. Additionally, the interviewees expressed their concern for the quality of the dam water, but also mentioned that various farmers still use the water for irrigation and further sell the products in supermarkets. However, farmers who collaborate with hotel chains seemingly are not allowed to extract water from the dams due to quality standards.

One interviewee mentioned that the high rates of evaporation from the dams leads to quicker depletion of the water, hence being a problem for farmers, while other interviewees stated the need for a limitation on the water extraction from the dams due to possible over-depletion. In general, the opinion seemed to be that the rooien and tankis work well, and that there should be more of them constructed on the island to mitigate the environmental effects of heavy rainfall.

Lastly, some interviewees expressed their concern for the lack of retention of water on the island. An interviewee stated that some dams have an impermeable bottom, leading to less infiltration and more erosion. One interviewee mentioned the need for vegetation on parking lots to allow for the infiltration of water and reduction of floods. Another interviewee stated how citizens on the island drill holes in their concrete fence to drain the rainwater from their property. Finally, the quotes in Table 3 act as supporting evidence for the key themes recognized in the interviews.

Table 3. Quotes from the interviews as supporting evidence

Rainwater quality and plants	**Functionality of *rooien* and *tanki*s**	**Water retention & flooding**
Interviewee 1: "In the past […] I try to take readings about different wells on the island that we know of. But that's more of the temperature and the salinity and the TDS, the basic water quality measurements." *Interviewee 2* stated that "Rainwater is the best water for plants. […] you can see the plant just it thrives on rainwater. […] through the plants and the growth and the green and everything." *Interviewee 2* also mentioned that, "actually, that's why I think the hotels don't allow it, to cultivate for them to get that water because it's not tested. So, we don't know if it's good." *Interviewee 3* commented on the quality of the water of the dams, "It's contaminated […] There's so much oil on the first surface, so you can physically see it. *Interviewee 5* commented on the quality measurements of the *tanki*s*:* "we have been doing this since 2007 [...] it's not accessible for everybody. "	*Interviewee 1* "And the wells that we do have my concern is that people will over extract because we are a dry island" *Interviewee 2:* "I think the farmers […] should take advantage of the moment that there is water because it will be gone very quickly. The sun will evaporate the whole thing in a few months and we won't have any more water"	*Interviewee 1* wants to see "More on dry riverbeds that are being properly maintained also to reduce or to hold as much of the water possible, to let it infiltrate into the ground. […] then you can put wells beside it and harvest that water through the wells and not through the dams itself." *Interviewee 1* when asked if there is flood management on the island: "Flood management? No, I don't think so." *Interviewee 3* "Specifically, if you look at the National Park. Yeah, there's not much retention areas. So if you want nature to flourish, you need water and water is the pillar of majority of things that you grow, so." *Interviewee 4:* "So I would see like to see more legislation to, for example, say you need to have at least so many percent square meters that can infiltrate water on your premises."

5. Discussion

By identifying various climatic and environmental conditions such as rainfall, natural structures, evapotranspiration, land use, flood management and climate change, one can determine what the challenges and facilitators of RWH in Aruba are. In this discussion, the environmental facilitators and challenges for RWH will be explored.

The obvious environmental factor that affects RWH in Aruba is rain itself. Many respondents of the survey in the context of this research found the lack of rainfall as one of the main barriers for RWH. However, rainfall can also be considered an environmental facilitator, due to its abundance in Aruba. Rain is a clean resource and has great chemical properties for plant growth, as mentioned by I2 "[…] you can see the plant just it thrives on rainwater". In addition to this, the rainwater on the island also allows for the recharge of stream systems, such as rooien, tankis, and groundwater reserves (Scalley, 2012). Hence, for example redirecting the water towards areas of abundant vegetation with the help of RWH systems would have a positive effect on plant growth as well as groundwater levels.

The *rooien* and *tankis* on the island have acted as RWH systems for years and continue to benefit the population today. They not only allow for an extra supply of water for e.g. farmers, but also help with flood risk management and water infiltration into groundwater reserves. However, as I1 stated, due to possible over-extraction, the quality of the ecosystem services of the *tankis* will decrease. Here's where RWH comes into the picture. Developing urban and rural RWH structures would increase the water supply, thus possibly lowering the extraction rates of water from the tankis. This would not only enhance the water security on the island but also allow for the water of the dams to infiltrate into the ground, replenishing the groundwater reserves. Hence, shifting the focus to RWH could improve the natural situation of the *tankis* and the groundwater, since, according to Van Houselt (2021) "an insufficient recharge of groundwater will result in a shrinking freshwater buffer and cause water stress". Additionally, Kundzewicz (2009) mentioned that semi-arid and coastal regions are often affected by climate change through changes in groundwater recharge, and Borst & De Haas (2005) have stated that the quality and quantity of groundwater can be increased through the retention of rainwater in e.g. dams, based on a hydrological research in Bonaire.

Increasing RWH on a household level could also lower the use of sewage water for irrigation. The survey conducted showed that sewage, washing machine, dishwasher, and shower water is prominently reused for irrigation by the respondents (see Table 2). Additionally, I1 stated that "most of our sewage water tends to go into the ground rather than treat it on the island". Although there is not enough research on the negative impacts of wastewater on groundwater and soil quality in Aruba specifically, various studies have shown that wastewater, such as sewage water pollutes the soil with heavy metals. Heavy metals can have an impact on soil fertility, groundwater quality and even have possible health risks (Sial et al., 2005).

The short and heavy rainfalls on Aruba can cause negative environmental effects such as flooding. In the interviews, respondents expressed the lack of flood mitigation infrastructure on the island, I1 stating "Flood management? No, I don't think so". According to a survey conducted in Aruba in 2010, 32% of households expressed an inconvenience from flooding after heavy rains. Additionally, 82% of the residents in flood-prone areas on the island expressed an increase in flooding inconvenience from the year 2000 to 2010 (Derix, 2016d). This suggests that the increase in construction increases the risks and inconveniences of flooding, since the rate of construction was relatively high between 2000 and 2010 (Derix, 2016c). The survey answers for this research have come to a similar conclusion, with 78% of the respondents expressing that flooding causes them problems (see Figure 1.).

Runoff and erosion are also common effects of heavy rainfall, which often leads to the loss of fertile topsoil as well as the runoff of materials into the sea (Van Houselt, 2021). A way to mitigate flooding and erosion on the island could be RWH. Not only urban areas, but also rural and natural areas could benefit from RWH structures that redirect or collect the rainwater. As mentioned in the introduction, RWH has been proven to reduce stormwater runoff by 20-50% (Hofman & Paalman, 2014).

Lastly, one of the key sustainable goals in Aruba is the strive for a shift away from fossil fuels due to their negative impact on the environment. For this, RWH could be used, since an increase in rainwater use could decrease the demand for water from WEB, lowering the fossil-fuel dependent water production on the island, further decreasing the environmental impact of the industry.

6. Conclusion

This research has allowed for the identification of potential environmental effects that may influence RWH in Aruba. However, the environmental factors themselves have not been separately researched to understand their extent. For instance, investigating the infiltration and extraction rates in the *tankis* could provide insight into how a potential decrease in extraction rates may affect the infiltration. Secondly, due to the scope of this research project, a check for alternative explanations for the environmental factors with further environmental specialists on the island was not done. Therefore, the findings of this research may overlook certain aspects regarding the environment and climate of Aruba.

To answer the research question, *How does the identification of climatic and environmental conditions affect possible RWH system implementation?* a few things need to be considered. Environmental factors on the island can either facilitate the implementation of RWH, be a challenge for RWH, benefit from RWH, or all three at once. Rainwater has been identified as both a facilitator as well as a challenge for RWH in Aruba, the *rooien* and *tankis* are identified as functional structures and thus should be continuously used, however with proper maintenance and control. It was concluded that the implementation of urban and rural RWH structures may aid in the recovery of depleted natural structures and the groundwater on the island, and the increase in the water supply through RWH could help mitigate climate change by lowering the water production through desalination.

Lastly, it is important to identify these environmental factors, as they act as a base for the actual physical possibilities of RWH before considering implementing it in policy frameworks and the society. To conclude, most environmental factors identified in this paper facilitate the implementation of RWH, and may even further benefit from its implementation through e.g. less erosion and flooding. Additionally, RWH could provide the population of Aruba with another water supply and better growth for their plants.

7. References

- Batterton, K. A., & Hale, K. N. (2017). The Likert Scale What It Is and How To Use It. Phalanx, 50(2), 32–39. http://www.jstor.org/stable/26296382
- Croes, G. (2022). A Sustainable Energy Transition Case Study On Aruba. [Master's Thesis, Delft University of Technology] *Departamento Meteorologico Aruba.* (n.d.). www.meteo.aw. © 2011, www.meteo.aw. http://www.meteo.aw/climatnormals19912020.pdf
- Derix, R. (2016b). Landscape series no.3: A review of Geology, Climate and Hydrology in Aruba. Spatial and Environmental Statistics - Central Bureau of Statistics (CBS Aruba).
- Derix, R. (2016c). Landscape series no.4: The Suburbanization of the Aruban Landscape. Spatial and Environmental Statistics - Central Bureau of Statistics (CBS Aruba).
- Derix, R. (2016d). Landscape series no.6: Inconveniences in the home neighborhood in Aruba. Spatial and Environmental Statistics - Central Bureau of Statistics (CBS Aruba).
- evapotranspiration. Oxford Reference. Retrieved 27 Mar. 2024, from https://www.oxfordreference.com/view/10.1093/oi/authority.20110803095802297.
- Fabricius, K. (2005). Effects of terrestrial runoff on the ecology of corals and coral reefs: review and synthesis. *Marine Pollution Bulletin, 50*(2), 125–146. https://doi.org/10.1016/j.marpolbul.2004.11.028
- Ferreira, C. S. S., Potočki, K., Kapović-Solomun, M., & Kalantari, Z. (2021). Nature-based solutions for flood mitigation and resilience in urban areas. In *Nature-based solutions for flood mitigation: environmental and socio-economic aspects* (pp. 59-78). Cham: Springer International Publishing.
- Fletcher, T. D., Andrieu, H., & Hamel, P. (2013). Understanding, management and modelling of urban hydrology and its consequences for receiving waters: A state of the art. *Advances in Water Resources, 51*, 261–279. https://doi.org/10.1016/j.advwatres.2012.09.001
- Haviser, J. B., & Hofman, C. L. (2015). A review of archaeological research in the Dutch Caribbean. *Managing our Past into the Future: Archaeological Heritage Management in the Dutch Caribbean,* 37-70.
- Hofman, J. A. M. H., & Paalman, M. (2014). Rainwater harvesting, a sustainable solution for urban climate adaptation? (KfC 142/2014). KWR *Watercycle Research Institute.* https://edepot.wur.nl/345625
- Horn, A. (2017). Modelling urban floods in semiarid environment: a case study in Paradera, Aruba [Master's thesis, Wageningen University].
- Jurgens, S. S., Mijts, E., & Van Rompaey, A. (2024). Are there limits to growth of tourism on the Caribbean islands? Case-study Aruba. *Frontiers in Sustainable Tourism, 3*. https://doi.org/10.3389/frsut.2024.1292383
- Kundzewicz, Z. W., & Doell, P. (2009). Will groundwater ease freshwater stress under climate change?. *Hydrological sciences journal, 54*(4), 665-675.
- Limjuco, R. P., Quinamot, S. M. V., Guy-Ab, V. L., Cabañero, C. B., Tarongoy, B. P. B., Bruno, A. J. P., & Ybañez, E. B. (2016). The quality and effect on plant growth of tap water and rainwater in DAVAO CITY. *UIC Research Journal, 20*(2). https://doi.org/10.17158/502
- Peterson, R., Rendolf, A. L., Werleman, S., Tromp, L., Croes, G., Croes, E., & Kock, R. (2021). Governing from the future - Leading with Impact. Prospects, policies, and pathways for Aruba 2040. *In Centrale Bank Van Aruba.* https://www.cbaruba.org/readBlob.do?id=11995
- Reijtenbagh, R. (2010). Minimum design requirements for domestic rainwater-harvesting systems on small volcanic islands in the Eastern Caribbean to prevent related water quality and quantity issues.
- Scalley, T. H. (2012). FRESHWATER RESOURCES IN THE INSULAR CARIBBEAN: AN ENVIRONMENTAL PERSPECTIVE. *Caribbean Studies, 40*(2), 63–93. http://www.jstor.org/stable/41917604

- Sial, J. K., Bibi, S., & Qureshi, A. S. (2005). Environmental Impacts of Sewage Water Irrigation on Groundwater Quality. Pakistan Journal of Water Resources, 9(1), 49-53.
- Smart Water. (2024). *Rainwater vs Tap Water: What's the Difference?* https://smartwateronline.com/news/rainwater-vs-tap-water-whats-the-difference
- Soeder, D. J. (2020). Fossil fuels and climate change. In *Springer eBooks* (pp. 155–185). https://doi.org/10.1007/978-3-030-59121-2_9
- UNFCCC. (2005). Climate change - Small island developing states. In *UNFCCC Secretariat* (ISBN 92–9219–012–1). https://unfccc.int/resource/docs/publications/cc_sids.pdf
- Van Houselt, G. J. (2021). A Rainwater Harvesting System based Blueprint for Excess Runoff Management on Caribbean Small Island Developing States Investigating the Feasibility of the Rigofill System Combined with New Dam Structures in the Coral Estate Resort–Curacao [Master's thesis, Utrecht University].
- Van Sambeek, M. H., Eggenkamp, H. G. M., & Vissers, M. J. M. (2000). The groundwater quality of Aruba, Bonaire and Curaçao: a hydrogeochemical study. *Netherlands Journal of geosciences, 79*(4), 459-466.
- WEB Aruba N.V. (2024) High water bill?. Retrieved April 3, 2024 from https://webaruba.com/your-water-bill/high-water-bill
- WEB Aruba N.V. (2024). *Power Production Figures.* Retrieved March 28, 2024, from https://webaruba.com/energy/power-production-figures

Marta Ramos Monzón, Utrecht University

I feel as if I have already lived on this island.

I remember arriving at the airport on the 3rd of February as if it was yesterday, and at the same time, I feel as if I have already lived on this island for way more than two months. I started this experience with a feeling of vacation, as suddenly in the first week of February I was wearing shorts and going to the swimming pool. Little did I know in those first days how much love I would end up having for this island and being able to consider it a second home. What I was told beforehand was how nice and welcoming Arubans would be. And I have experienced this since day one. It is such a privilege to have been welcomed so well in such a beautiful community where I have met very kind people, whose smiles and joy I will always remember, from the elderly couple I talked to once in the supermarket to my very beloved Aruban classmates that now I consider friends.

Also, the unique natural environment of the island has captivated me every week I have spent and discovered new places. Having cacti surrounding me everywhere while doing a hike or seeing more than 20 lizards in one spot at the beach truly left me both surprised and amazed. I could make a very long list with all the places that have a place in my heart, but I want to highlight seeing the coral ecosystem and all the fish that live there and seeing sea turtles. These two experiences made me discover the ocean and its life below water in a way I have never done before. Also, I appreciate deeply having been able to see the sunset turn the water orange while swimming in the sea, and it became one of my favourite things to do in my time here.

All this and more, has made my time in Aruba a time for both personal and academic growth. Coming to do a consultancy project has allowed me to put into practice what I have learned in the last three years of university. It has also made me learn a lot of skills that you can only learn by doing a real-life project. It has been a pleasure to see the excitement for our contribution to our client Santa Rosa's mission. Having a department of the government communicating to you the value of our project and being able to see it as we lived in the community and engaged with it has given me great academic motivation. Furthermore, even in "paradise" life has its good and not-so-easy moments. And living these in Aruba has taught me a lot about myself and about the beauty of counting on and sharing this journey with amazing people. Masha danki Aruba.

Sustainable Water Governance: Exploring Political Factors Shaping Rainwater Harvesting Implementation in Aruba.

Marta Ramos Monzón

"If you have the right people and the right pulling systems, you can do it"

Introduction

Aruba is dedicated to sustainability, and the government of the island has committed to implementing the SDGs on a national scale. The visions of the government are "sustainable economic growth, a robust social welfare system, a strong focus on the marginalised in society, all the while in balance with the protection of the island's natural resources in order to improve the wellbeing of its citizens and align with the SGDs" (Overheid van Aruba, 2024). To make this vision a reality, it has set the objective of further shaping policy sustainably and strengthening implementation (Overheid van Aruba, 2024).

Water is an important sustainability challenge on the island, and it is addressed in SDG 6 on clean water and sanitation, as well as SDG 14 on life below water. The sources of freshwater, including rain and groundwater are limited due to the island's arid climate (Van Sambeek et al., 2000). The seasonality of rain makes this resource intermittent which reduces its availability. This can be worsened by climate change (Kaidou-Jeffrey et al., 2018). Furthermore, the island's past of natural resource exploitation during colonial rule disrupted the natural vegetation and water resources processes (Derix, 2016). These two freshwater sources, rain and groundwater, were the main resources used in the past for all purposes. However, since the beginning of the 20th century desalinated water was introduced as a new water resource for potable and non-potable purposes *(WEB Aruba N.V. | Water- En Energiebedrijf Aruba N.V.,* n.d.). Water desalination expanded and became the main supply of freshwater for all uses on the island, providing drinking and industrial water to all of the island. However, this supply has come with a huge carbon footprint, as the island's water production process is based on fossil fuels, as well as negatively impacts marine ecosystems in Aruba's surroundings (Marchena & Halman, 2018). Furthermore, this water resource's dependence on heavy fuel oil imports and monopoly in the supply brings vulnerability to external shocks. The water challenge is very interconnected with the food security challenge on the island. Local food production is very limited; however, the growth of sustainable agriculture is key to achieving food resilience and security, which is covered in SDG 2 on zero hunger (United Nations, n.d.). Now, water for agriculture is either supplied from desalination or freshwater sources. Relying on water supply from desalination comes with high economic costs, as explained by Cooley et al. (2006), even the lower price of desalinated water is still above the price of water typically paid in urban environments and well above the price paid by farmers.

Political institutions have a fundamental role in the navigation of these sustainability challenges and taking action to achieve sustainability goals by setting them in the agenda and putting them into practice (Jordan, 2008). Political decisions, policy-making and institutional and regulatory frameworks are essential in effectively achieving Aruba's sustainability goals. Furthermore, the political decisions that have been made in the past have shaped the challenges that Aruba faces today. Therefore, the current sustainability governance must work towards reducing the carbon footprint of the water supply, increasing resilience to crises by empowering independence of the water and food production processes, equitable and affordable water supply, and decreasing the environmental impacts of water production. Rainwater harvesting is considered one of the most sustainable water supplies by Rahman et al. (2014) and thus can contribute to tackling some of the previously mentioned sustainability challenges. Water management, and specifically rainwater harvesting on the island, can be influenced by political decisions, policy-making, regulatory frameworks and other political factors. However, there is a gap in research on these influences in Aruba's rainwater management. Therefore, this paper aims to provide an overview of what barriers and challenges shall be considered in the governance of sustainable water management, by specifically presenting these factors that may influence the implementation of rainwater harvesting in Aruba. To achieve this aim, the following main research question will be answered: *How do past and present political factors influence the implementation of RWH systems in Aruba?*

The paper is structured as follows: first, a methods section explains how the data is collected and analysed. Then, the theory section introduces the relevant concepts and literature. After this, the results are presented, followed by a discussion and conclusion as the final section, including a reflection on the methods and results, together with suggestions for further research.

Methods

In order to answer the research question and sub-questions, a combination of methods was used, including a literature review, a survey and interviews. This is possible as this paper is written in alignment with the Consultancy Project which advises Santa Rosa, the Department of Agriculture, Husbandry and Fisheries (DLVV), on the wider political, environmental, and socio-economic factors shaping rainwater harvesting in Aruba. A literature review was used to gather knowledge on the context of water supply in Aruba and to build the theory for creating a conceptual framework. For this, the main search engine used was Google Scholar and WorldCat and journal articles and reports were analysed. Some of the main search terms involved were "water management", "political determinants", and "water supply in Aruba". This analysis allowed for the determination of the most relevant political influences in a policy implementation process, which in turn allowed to build a conceptual framework that was used then to analyse the current implementation of rainwater in Aruba from a political perspective. This analysis was based on the information obtained from the survey and interviews carried out for the Consultancy Project. Some of the survey questions relevant to this paper concerned the societal opinion on RWH and the perceptions of political support and barriers. For instance, *"What are existing barriers for you or other people to collect rainwater?"*, *"Opinions on rainwater harvesting"*, and the opinion statement: *"The government should initiate rainwater harvesting system implementation (policies, financial support, etc.)"*. The semi-structured interviews aimed at understanding in-depth the perspectives of the past and present political influences on RWH on the island from the different sectors: governmental departments, consulting engineers, a farmers' organisation, a general citizen and farmer, and the hotel industry. Some of the questions asked were: *"What are the political challenges of RWH system implementation?"*, *"Do you think there are any conflicting interests from the government in supporting*

RWH?”, and *“Do you think the government should support more RWH? If so, in what way?”* Then, data analysis for the interviews was carried out with the software NVivo, as suggested by Bryman (2012), and classified into codes, which correspond to the selected factors developed in the conceptual framework.

Theory

Water management

The implementation of rainwater harvesting, from a political perspective, is part of the concept of water resources management. This is defined as *“measures taken to ensure an adequate supply of water and a responsible utilisation of water resources”* by *UNEP Law and Environment Assistance Platform* (n.d.). Literature that places water management in the context of climate change and sustainability transitions, highlights the importance of including flexibility in water management to be able to deal with the uncertain changes and challenges that adapting to the climate crisis context may bring. It is also recommended by Bouwer (2000) that an integrated water management approach is taken, where all the relevant factors of this transition are taken into account in the process of decision-making, which is advocated particularly for agricultural water management.

Rainwater Harvesting

Literature on the development of rainwater harvesting globally, shows that currently in many countries RWH is not only considered a viable decentralised water source but also that RWH is practised as a sustainable development strategy (Yannopoulos et al., 2019). Nonetheless, the extended use of this water resource is limited and faces some challenges that need to be overcome in a combined effort by research, financial support, education, legislation, and regulations (Yannopoulos et al., 2019). Specifically for dry climates like Aruba, the climatic vulnerabilities posed by climate change not only affect the rain patterns but also the natural recharge of groundwater, which shows the interconnection between these two resources. The study by Bouwer (2000) suggests increasing the water storage capacity and long-term availability during periods when water is more abundant to deal with climatic extremes and changes.

RWH Implementation determinants

The importance of political factors’ influence in the management of rainwater harvesting cannot be overlooked. This is supported by the literature on the analysis of factors affecting governance reforms across different countries, where it is stated that the implementation of successful governance reforms can be frustrated if political factors are not considered properly (Robinson, 2007).

Results

The report on Integrated Water Resources Management in the Caribbean: The Challenges Facing Small Island Developing States (2014) highlights the importance of legislation. The drafting and adoption of legislation is identified as a key element for the improvement of water governance, adding that this contributes to having a facilitating environment and establishes an institutional framework. The survey and interviews indicate that legislation has a significant impact on water resources management. From a historical perspective, it especially affected rainwater harvesting, as the legislation established in the 1960s prohibited the construction of “regenbakken” (traditional rainwater cisterns) in new houses (Interviewee 1, personal communication, March 14, 2024). This legislation had strong impacts on the practices of rainwater collection, as during this period the population of Aruba grew exponentially and the number of houses constructed increased greatly, while the practice of household RWH abruptly ended. As a consequence, most new houses do not have RWH systems, the traditional “regenbakken” (Interviewee 1, personal communication, March 14, 2024); (Interviewee 7, personal communication, April 2, 2024). In 2008 this legislation was annulled (Interviewee 1, personal communication, March 2024), despite this, the survey reveals that the effects of this prohibition are still visible nowadays. For example, in response to the question *"What are existing barriers for you or other people to collect rainwater?"*, the lack of building RWH infrastructure in the construction of their households was given. In addition, 3 out of the 101 survey respondents, as well as several interviewees, are not aware that this prohibition is not in place anymore nowadays. This also shapes the societal consideration of implementing RWH today.

Furthermore, a study on the determinants of policy-making and implementation in Bangladesh carried out by Aminuzzaman (2013) identified donor support and conditionality, political will, professional skills of the public bureaucracy, and resources and supportive regulatory frameworks as factors to assess this influence. Aminuzzaman concludes that the determinants that have a stronger ability to influence the policy processes are the first three. Similarly, Quinn (1973) describes limited jurisdiction, planning responsibilities and operational responsibilities integration as institutional and political factors that affected water management in the Upper Wabash Basin. In the interview with the representative of a governmental department conducted in the framework of this research, political will was identified as a barrier to translating the measures related to RWH that are in the planning phase into real implementation (Interviewee 2, personal communication, March 22, 2024).

Robinson (2007) carried out a comparative analysis of nine cases of governance reforms in Brazil, India and Uganda, and also identified several factors that affected a reform. One of them is political commitment from the higher levels of the government, described as important to have a more successful implementation and diffuse resistance. The timing and sequencing of reforms is another factor categorised as key to having a successful reform. This was confirmed by one of the interviewees from a governmental department when asked if there was a possibility for political support for larger RWH implementation. The answer was "If you have the right people and the right pulling systems, you can do it" (Interviewee 2, personal communication, March 22, 2024).

Bureaucratic technical capacity and societal pressures are other factors identified by Robinson (2007). These were also present in the interview answers of a representative of a governmental department: "The more support you have from the local people, the more likely it is put on the agenda" (Interviewee 2, personal communication, March 22, 2024). Bureaucracy was also discussed, explaining that the legislation is a considerably slow process in Aruba and counts with a reduced number of workers compared to other countries (Interviewee 1, personal communication, March 14, 2024). The potential for societal pressure for RWH implementation in Aruba depends on the citizens' perception and opinion on the water resource. It has been found that 52 out of 101 participants of the survey collect rainwater in their households. The majority of the respondents think rainwater harvesting could bring them benefits, so there is a generally positive opinion on this water resource within our population sample. For the respondents, these advantages mainly concern a decrease in the water bill, or a decrease in the use of desalinated water, and finally, respondents state that rainwater is beneficial for plants. This last observation is related to the finding that the most common use of rainwater is in agriculture and gardening. Looking into the different stakeholders' potential support for rainwater harvesting, it has been found that the governmental departments DOW and DNM support rainwater collection. The interviewee representing the hotel industry explained that, in their hotel there is currently a process of installing rainwater collection systems, and believes this water resource can be useful for non-potable purposes (Interviewee 6, personal communication, April 2, 2024). Adding to this, a report on Integrated Water Resources Management in the Caribbean describes that to have the support of water sector bureaucrats and professionals to act as agents of change, incentives are needed. It is explained further that the explicit support of government administrative processes is key to creating change in the water sector (Global Water Partnership, 2014).

Discussion and Conclusion

To answer the research question: *How do past and present political factors influence the implementation of RWH systems in Aruba?* several political factors that influence water management have been identified through a literature review, a survey, and interviews. The determinants most mentioned in both literature and fieldwork can be grouped into: legislation, political will, bureaucracy, and societal pressure. Therefore, the relevance of these is supported by a wide range of studies carried out regarding governance in the Caribbean and globally and the input of these studies was contextualised for Aruba by the interviewee's experiences.

To further interpret the influence that these identified political and governance factors have on the implementation of Rainwater harvesting, they can be analysed as barriers and opportunities. The political determinants that may be identified as barriers in the context of Aruba include legislation, bureaucracy and political will. The 1960s prohibition of new houses with "regenbakken" caused a drastic reduction in the collection of rainwater practice and capacity, and nowadays, it still hinders the society's consideration of RWH implementation, as some citizens still consider that this is not allowed, there is a lack the infrastructure in their households, and have unlearned how to harvest rainwater. Bureaucracy and political will hinder the measures in the planning stages to reach the implementation phase. Moreover, the determinants that may be identified as opportunities for political support of RWH implementation in the context of Aruba are societal pressures. The survey revealed the general support for RWH systems and implementation in the participants' households and farms. With an increase in this support, societal pressure can favour the implementation of rainwater harvesting.

This research has provided valuable insights that can be taken into consideration by policy-makers and civil society that want to know the factors that can influence the implementation of rainwater harvesting. However, more extensive research would lead to more in-depth knowledge of the effects that these political factors have. The population sample can be enlarged and using random sampling methods would allow for a higher representation of the Aruban society. In addition, this research can be combined with the study of other relevant factors that can also have an influence on water governance, like environmental or economic determinants.

References:

- Aminuzzaman, S. M. (2013). Dynamics of Public Policy: Determinants of policymaking and Implementation in Bangladesh. *Public Organization Review, 13*(4), 443–458. https://doi.org/10.1007/s11115-013-0262-7
- Bouwer, H. (2000). Integrated water management: emerging issues and challenges. *Agricultural Water Management, 45*(3), 217–228. https://doi.org/10.1016/s0378-3774(00)00092-5
- Bryman, A. (2012). *Social research methods.* Fourth edition. Oxford University press.
- Cooley, H., Gleick, P. H., & Wolff, G. (2006). Desalination, with a grain of salt: a California Perspective. Pacific Institute.
- Global Water Partnership. (2014). Integrated Water Resources Management in the Caribbean: The challenges facing small island developing States. In GWP Technical Committee. Retrieved April 1, 2024, from https://www.gwp.org/globalassets/global/toolbox/publications/technical-focus-papers/04-caribbean_tfp_2014.pdf
- Jordan, A. (2008). The governance of sustainable development: taking stock and looking forwards. *Environment and Planning C-government and Policy, 26*(1), 17–33. https://doi.org/10.1068/cav6
- Kaidou-Jeffrey, D., Kendall, P., Peters, A. C., & Ram, J. (2018). Managing Water Resources for Sustainable Development in the Caribbean: Dynamic Policy Options. *Social and Economic Studies, 67*(4), 37–66. http://www.jstor.org/stable/45204453
- Marchena, F. A., & Halman, J. I. (2018). Aruba's desalination's knowledge and experience: Conquering the sea toward desalination's sustainability. *AQUA-LAC, 10*(1), 39–50. https://doi.org/10.29104/phi-2018-aqualac-v10-n1-04
- Quinn, M. C. (1973). *The impact of institutional and political factors on water management in the Upper Wabash Basin.* IWRRC Technical Reports. http://docs.lib.purdue.edu/watertech/35
- Rahman, S., Khan, M. T. R., Akib, S., Din, N. B. C., Biswas, S. K., & Shirazi, S. M. (2014). Sustainability of rainwater harvesting system in terms of water quality. *The Scientific World Journal,* 2014.
- Robinson, M. (2007). The Politics of Successful Governance Reforms: Lessons of design and implementation. *Commonwealth & Comparative Politics, 45*(4), 521–548. https://doi.org/10.1080/14662040701659944
- Derix, R. W. M. (2016). The history of resource exploitation in Aruba. *Spatial Developments in the Aruban Landscape: A Multidisciplinary GIS-based Approach Derived From Geologic, Historic, Economic and Housing Information.* https://cbs.aw/wp/wp-content/uploads/2016/12/H2_LandscapeSeries_The_History_Of_Resource_Exploitation_In_Aruba_10-10-2016-1.pdf
- Overheid van Aruba. (2024, January 20). Capacity building for the implementation of the sustainable SDGs in Aruba. *Overheid van Aruba.* https://www.gobierno.aw/nl/capacity-building-for-the-implementation-of-the-sustainable-sdgs-in-aruba
- United Nations. (n.d.). Goal 2 | *Department of Economic and Social Affairs.* https://sdgs.un.org/goals/goal2
- Van Sambeek, M., Eggenkamp, H., & Vissers, M. (2000). The groundwater quality of Aruba, Bonaire and Curaçao: A hydrogeochemical study. *Netherlands Journal of Geosciences, 79*(4), 459-466. doi:10.1017/S0016774600021958
- *Water resources management | UNEP Law and Environment Assistance Platform.* (n.d.). https://leap.unep.org/en/knowledge/glossary/water-resources-management
- *WEB Aruba N.V. | Water- en Energiebedrijf Aruba N.V.* (n.d.). https://webaruba.com/water-production/water-production-history
- Yannopoulos, S., Giannopoulou, I., & Kaiafa-Saropoulou, M. (2019). Investigation of the current situation and prospects for the development of rainwater harvesting as a tool to confront water scarcity worldwide. *Water, 11*(10), 2168. https://doi.org/10.3390/w11102168

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